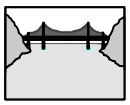
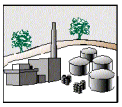


Appendix II-A
What the Assessment Must Include

The Columbia River Comprehensive Impact Assessment (CRCIA) examines the process of exposure and harmful effects on humans, ecosystems, and cultures (affected entities) of Hanford-derived and Hanford-related contaminants in the Columbia River. The requirements in this appendix define what factors must be included in assessing river impact to understand this process. These factors, compiled for each segment of the exposure process and variant scenarios (Sections II-A.1 through II-A.10), constitute the all-inclusive set of candidates to be considered in the assessment. They are winnowed to a manageable study set defined in Appendix II-B. The winnowing process is specified in Appendix II-C.

An acceptable comprehensive assessment must examine Hanford Site materials and contaminants, their containment and eventual release, and their transport and entry into the Columbia River. The assessment must also examine potential receptors, their exposure to Hanford-derived contaminants in the Columbia River, and the impact resulting from the estimated levels of exposure. The assessment must either include the specified candidate factors, or, if a factor is not included, the assessment must contain an evaluation that explains why the factor was not included.

The factors required to understand the process of exposure and harmful effects (described in Sections II-A.1 through II-A.9) are based on current environmental conditions and the disposition baseline for Hanford Site radioactive and hazardous materials (described in Section II-A.11). Variations from the current conditions are described in Section II-A.10. The extent to which each factor is to be assessed, that is, how well the analysis is to be performed, is defined in Appendix II-B. How the assessment should be conducted is defined in Appendix II-C. How the assessment should be managed is defined in Appendix II-D.



A.1 Hanford Materials and Contaminants (Sources and Inventories)

The requirements in this section call for all contamination sources within and adjacent to the boundaries of the Hanford Site to be considered in a composite source term for assessing impact to affected entities of the Columbia River. The impact of the entire inventory of radioactive and hazardous materials must be determined over time. This includes materials that are not contained, such as those contaminating the vadose zone of the Hanford Site. It also includes materials owned or managed by entities other than the U.S. Department of Energy (DOE), such as U.S. Ecology Incorporated and the Siemens Nuclear Fuels. The inventory will include estimates of future materials, whether imported to the Hanford Site or generated on or nearby the Site. This section requires the analyst to show that the list of potential contaminants used in the assessment is complete. This section also requires the analyst to rank all candidate contaminants according to CRCIA criteria developed to screen contaminants by their potential contribution to harmful

effects. The ranking will enable the assessment effort to always focus on the dominant contaminants regardless of the level of resources allocated to CRCIA (see Appendix II-B). The following is an overview of the requirements in this section:

(A1.0-1) All existing and potential contaminants and contaminant sources shall be identified, characterized, and ranked for significance of potential impact. The characterization shall include atomic or molecular composition, mass, and location. It also shall include reactivity, solubility, and mobility. Materials shall be defined explicitly enough to support tracing their movement through the media along their pathway to the Columbia River.

(A1.0-2) A method shall be developed to demonstrate and document completeness of the lists of inventory sources and their compositions used in the assessment.

A.1.1 Required Candidate Contaminants Set

The requirements in this section call for a Candidate Contaminants Set that identifies all the materials and contaminants whose contributions to harmful effects are potentially of concern. The requirements in this section are as follows:

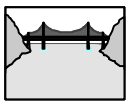
(A1.1-1) The Candidate Contaminants Set shall be formed by identifying all the radioisotopes and chemicals that are known to have a harmful impact on humans, cultures, or ecosystems and are known to be on the Hanford Site, as determined by established criteria.

(A1.1-2) Criteria for the completeness of the range of contaminants to be included in the Candidate Contaminants Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A1.1-3) Chemicals that mobilize contaminants shall be included in the Candidate Contaminants Set. An example is ethylenediamine-N,N,N',N'-tetra acetic acid (EDTA).

A.1.2 Required Candidate Inventories Set

The requirements in this section call for a Candidate Inventories Set that identifies all the inventories whose contributions to harmful effects are potentially of concern. These include present inventories, as well as those from future missions, that contain any of the radioisotopes or chemicals in the Candidate Contaminants Set. They include all inventories on the Hanford Site regardless of who owns or is responsible for them. Examples of owners are DOE, U.S. Ecology Incorporated, Siemens Power Corporation, Washington Public Power Supply System, and the U.S. Navy. The requirements in this section are as follows:



(A1.2-1) The Candidate Inventories Set shall be formed by identifying all the inventories that contain any contaminants belonging to the Candidate Contaminants Set, as determined by established criteria.

(a) Present inventories and those to be added by future missions shall be included.

(b) All inventories on the Hanford Site shall be included regardless of who owns or is responsible for them. Although not complete, the following are examples of inventories that shall be included:

- residual pre-1970 transuranic solid waste
- burial grounds waste, such as that contained at 618-10 and 618-11
- Non-Radioactive Dangerous Waste Landfill
- projected mass of contaminants from the Environmental Restoration Disposal Facility
- submarine reactor cores
- Resource Conservation and Recovery Act (RCRA) storage and disposal sites
- U.S. Ecology Incorporated site
- Advanced Nuclear Fuels at the Siemens Power Corporation site
- Washington Public Power Supply System materials and contaminants
- laundries handling anti-contamination clothing
- residual waste inventory from the Liquid Effluent Retention Facility and similar treatment facilities
- routine permitted releases, such as National Pollution Discharge Elimination System (NPDES) or National Emission Standards for Hazardous Air Pollutants (NESHAP)
- spent nuclear fuel storage sites, such as K Basins, including water, sludge, and structure
- inventories associated with retention basins
- inventories associated with 100 Area reactors, including reactor cores
- inventories associated with T-Plant facilities
- inventories associated with B-Plant facilities and cesium capsules
- inventories associated with Plutonium Uranium Extraction (PUREX) facilities
- inventories associated with Fast Flux Test Facility (FFTF) facilities
- special nuclear materials inventories, including N Reactor spent fuel and the proposed spent nuclear fuel inventory for the Containment Storage Building
- groundwater inventories, for example, dense and light phase non-aqueous liquid inventories
- saturated zone inventories on soils
- contaminants inventories in liquid effluent disposal facilities, such as cribs and French drains
- inventories associated with decontaminated and decommissioned facilities
- inventories associated with interim stabilized facilities

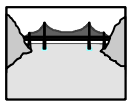
(c) Residual materials (contaminants) expected to remain on the Hanford Site after retrieval and after remedial goals have been met shall be included. Although not complete, the following are examples of inventories that shall be included:
- contaminant inventories expected to remain in the saturated zone
- material inventories expected to remain in tank structures
- contaminant inventories expected to remain in the vadose zone, including those located below excavation depth
- contaminated sediment inventories expected to remain in the Hanford Reach, including sloughs
- parent contaminants and their degradation and reaction products, such as chromium (including Cr III and Cr VI), carbon tetrachloride, trichloroethylene (TCE), and TCE degradation products
- materials known to have been produced but lost to the accessible environment

(d) Inventories that contaminate the following locations shall be included:
- lower Columbia River shoreline and sediment from McNary Dam to the Pacific Ocean
- McNary Pool shoreline and sediment
- lower Columbia River dams pool sediment
- tidal area sediment at the mouth of the Columbia River
- Port of Pasco and Kennewick sediment
- shoreline at the 300 Area
- shoreline between the Hanford town site and land leased by the Washington Public Power Supply System
- shoreline at the Hanford town site
- shoreline at the 100 Area
- North Slope shoreline
- upstream of the 100 Area

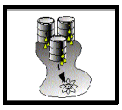
(e) Inventories created by hazardous materials introduced in the course of cleanup activities shall be included. An example is the material inventories accumulated from in-situ REDOX projects and that might be released at undesirable concentrations in the future, such as uranium at breakdown of the REDOX barrier.

(A1.2-2) Criteria for determining the completeness of the range of inventories to be included in the Candidate Inventories Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A1.2-3) Inventory masses shall be established and reconciled with known reactor production quantities and chemical input to the Hanford Site. Estimates of lost materials that may remain in the local environment shall be included in the reconciliation.



(A1.2-4) Decay of radionuclides and production of radioactive daughters shall be accounted for in inventories and throughout their transport to the Columbia River and uptake by receptors.



A.2 Containment Failure and Contaminant Release

The requirements in this section call for assessing potential contamination of the Columbia River that could result from eventual containment failure. Radionuclides and hazardous chemicals are contained during disposal operations by some form of engineered containment. Over time, all containment will eventually fail, allowing leaks into the surrounding soil, air, or water. The analyst shall determine when containment failure is projected to occur and the rate at which contaminants are projected to be released when containment fails. The following is an overview of the requirements in this section:

(A2.0-1) A projected time of containment failure for each isolation form shall be determined based on the method of containment selected in the approved disposal plan. If disposal plans (see Section II-A.11) include defensible estimates of containment durability, these will be used. It is anticipated that uncertainties in time to containment failure for a disposal form will require representation in terms of statistical distributions. Distributions may need to be parameterized on isolation form attributes, depending on the specificity of isolation form definitions. Examples of attributes are the type of barrier and glass formulation applied.

(A2.0-2) The projected rates of release from each form of isolation after containment failure (progression of containment deterioration) shall be determined based on approved disposal plans, where available, according to Section II-A.11.

(A2.0-3) Determination of release rates shall be consistent with external migration rates in adjacent soils.

(A2.0-4) The following shall be included in formulating shallow land burial site evaluations:

(a) The engineered barrier description used in the assessment shall be the "Hanford Site Disposition Baseline" (see Section II-A.11) as approved by the responsible agency (DOE, Ecology, EPA, Washington Public Power Supply System) and the appropriate regulatory agency. Where no baseline exists, the guidance of the responsible agency shall be used with regulator concurrence.

(b) Approved barriers and other mobility inhibiting actions, as well as barrier failure scenarios, shall be included.

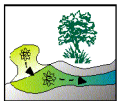
(c) Migration of Hanford contaminants under all applicable types of barriers in non-uniform geologic media shall be included. An example of this is accelerated lateral dispersion due to caliche layers.

A.2.1 Required Candidate Containment Failure Scenarios Set

The requirements in this section call for a Candidate Containment Failure Scenarios Set that identifies all the scenarios contributing to contaminant release into the adjacent environment. The requirements in this section are as follows:

(A2.1-1) The Candidate Containment Failure Scenarios Set shall be formed by identifying all the individual containment failure scenarios, both those with high likelihood and those that possibly could lead to the shortest containment failure time and initial contaminant release and/or the highest rate of contaminant release following containment failure.

(A2.1-2) Criteria for determining the completeness of the range of containment failure scenarios to be included in the Candidate Containment Failure Scenarios Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.



A.3 Transport Mechanisms and Pathways to the Columbia River

The requirements in this section call for assessing the transport of Hanford-derived contaminants to the Columbia River. Existing transport models shall be used to the extent that they satisfy the following requirements:

(A3.0-1) Contaminant transport through the vadose zone to groundwater shall be assessed.

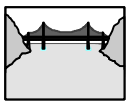
(A3.0-2) Contaminant transport through the groundwater to the Columbia River shall be assessed.

(A3.0-3) Transport characteristics of geologic formations, such as the Hanford formation and Ringold formation, shall be established to the degree needed to support the assessment.

(A3.0-4) All other paths of Hanford-derived contaminants to the Columbia River shall be considered. This shall include but not be limited to atmospheric transport, direct discharges, and transport of contaminants to the Columbia River by humans, either via personal contamination or intentional transport of materials, or by contaminated plants and animals.

(A3.0-5) Migration rates to and concentrations in the Columbia River of all contaminants shall be determined, including estimates of holdup periods in travel time calculations.

(A3.0-6) Chemical forms and physical characteristics of radionuclides, such as solubility and sorption rates, shall be considered to the extent that migration rates are affected. This consideration shall include probable modifications of the original contaminants' characteristics as contact is made with soils, groundwater chemistry, and other contaminants.



(A3.0-7) Decay of radionuclides during transport shall be evaluated.

A.3.1 Required Candidate Transport Paths Set

The requirements in this section call for producing a Candidate Transport Paths Set that identifies the paths and the associated geologic features that potentially contribute to contaminant migration to the Columbia River. The requirements in this section are as follows:

(A3.1-1) The Candidate Transport Paths Set shall be formed by identifying all potential paths for contaminant migration from existing and projected inventories to the Columbia river.

(A3.1-2) Criteria for determining the completeness of the range of transport paths to be included in the Candidate Transport Paths Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A3.1-3) Geologic features associated with each path shall be identified. An example is an aquifer.

(A3.1-4) Both confined and unconfined aquifers shall be included in the Candidate Transport Paths Set.

(A3.1-5) Transport mechanisms associated with each path shall be identified.

A.3.2 Hydrogeologic Characterization

The requirements in this section call for identifying hydrogeologic parameters to support contaminant concentration estimates in the Columbia River. The requirements in this section are as follows:

(A3.2-1) Stratigraphy, including thickness, lateral extent, continuity of units, and pathways, shall be established.

(A3.2-2) The effect of geochemistry on migration rates shall be identified. An example is the retardation of the rate of contaminant migration.

(A3.2-3) Hydraulic conductivity, storage coefficient, and effective porosity shall be established.

(A3.2-4) Geochemical characterization shall include identifying the following:

(a) changes in mobility brought about by remediation and technical development

(b) the effects of chelating agents, such as EDTA

(c) the long-term effects of chemicals introduced in connection with or as a part of remediation. An example is sodium dithionate weathering in contact with groundwater whose pH and dissolved oxygen change.

A.3.3 Contaminant Migration in the Vadose Zone

The requirements in this section call for assessing radioisotope and chemical migration through the vadose zone to the groundwater. The vadose zone is located between the land surface and the saturated groundwater zone. Interfaces of the vadose zone with the surface boundary and with the saturated groundwater zone shall be addressed. The vadose zone can also be geographically subdivided over the Hanford Site for analysis. Consistency shall be maintained across geographic subdivisions. Infiltration entering at or near the surface plays an important role in contaminant migration. The requirements in this section are as follows:

(A3.3-1) Assessment of the interface of the vadose zone with the land surface shall identify the following:

(a) effects of infiltration on vadose contaminant migration rates

(b) effects of permitted discharges on vadose contaminant migration rates

(c) effects of discharged chemicals on mobilization of contaminants and consequent vadose contaminant migration rates

(A3.3-2) In assessing the interface of the vadose zone with the groundwater zone, the following shall be represented:

(a) migration of contaminants to soils immediately adjacent to containment packages, especially as saturated with escaped effluents

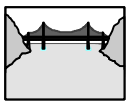
(b) migration from vadose zone to saturated zone groundwater

(c) mixing of contaminants from vadose zone with saturated zone groundwater

A.3.4 Contaminant Migration in Groundwater

The requirements in this section call for representing radioisotope and chemical migration through the groundwater to the Columbia River. The requirements in this section are as follows:

(A3.4-1) Contaminant migration rates in groundwater from its source at the interface with the vadose zone to the river shall be identified.



(A3.4-2) Interaction between confined and unconfined aquifers and contamination transport shall be identified.

A.3.5 Contaminant Transport to the River by Intruders

The requirement in this section calls for evaluating the movement of disposed waste by intruders who physically remove the waste to the Columbia River, either inadvertently or knowingly. An example is mining of fissionable materials. The requirement in this section is as follows:

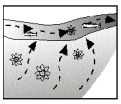
(A3.5-1) The transport rates and concentrations caused by intrusion scenarios shall be identified.

A.3.6 Contaminant Migration in Air

The requirements in this section call for assessing airborne radioisotope and chemical transport of surface contamination or disposed waste to the Columbia River. Some Hanford contaminants may migrate to the Columbia River with offsite waste water and runoff from irrigation projects. These contaminants would originally have been wind-deposited offsite and washed back into the river by erosion. The requirements in this section are as follows:

(A3.6-1) Wind patterns within the Columbia River watershed shall be assessed and documented. Wind pattern data provided by the State of Oregon shall be evaluated.

(A3.6-2) The effects on the Columbia River from deposition and redeposition of airborne contaminants from the Hanford Site shall be identified.



A.4 Contaminant Entry into the Columbia River

The requirements in this section call for determining entry locations and flux of contaminants as they enter the river. Model and geological/hydrological description requirements shall be established for introducing Hanford-derived contaminants into the Columbia River through groundwater. The rates and locations of contaminant influx to the river shall support investigations to determine potential contaminant distribution in the river (Section II-A.5).

Currently, the Hanford Site groundwater with contaminants discharges into the Columbia River through seeps, springs, and river bottom (for example, gravel substrate). Potentially, contaminants could also be introduced with surface water during storms. Contaminants in dissolved, colloidal, and particulate form enter the river through these paths.

Contaminated groundwater mixes with surface water. The groundwater contamination concentrations are eventually diluted to bulk river concentrations. Mixing begins in porous river bottom and is complete at a currently unspecified distance downstream from each given entry point.

Some of these contaminants can compromise the health of the river ecosystem. For example, early life stages of fish are susceptible to the toxic effects of hexavalent chromium that enters the gravel substrate of the Columbia River bottom. Section II-A.6 addresses the correlation of critical habitat locations with contaminant concentrations.

Groundwater influx, though difficult to quantify, shall be defined. If generalizations are used instead of field data, potentially high concentrations in critical locations may be missed. Groundwater influx locations shall be identified, the groundwater at those locations characterized, and the groundwater and expected contaminant loading quantified. The relationship between groundwater influx and river flow (for example, dam operations) shall be established. The hydraulic conductivity at a given location greatly affects the amount and concentration of contaminant entering the river at that location. The following is an overview of the requirements in this section:

(A4.0-1) Groundwater and surface water interactions shall be identified.

(A4.0-2) The interface with the Columbia River, including seeps, springs, and sub-surface influx into the river, shall be identified to support the assessment of biota exposures in the riparian zone and near the river bottom as required in Section II-A.8.

(A4.0-3) The groundwater interface with the Columbia River, seeps, springs, and sub-surface influx shall be identified to support assessment of contaminant distribution in the river.

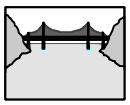
(A4.0-4) Valid interfaces shall be defined between groundwater transport assessment and the assessment of groundwater introduction into the Columbia River.

A.4.1 Required Candidate River Entry Location Set

The requirements in this section call for a Candidate River Entry Location Set that identifies river entry regions which are potential sources of harmful contaminants in the river. The requirements in this section are as follows:

(A4.1-1) The Candidate River Entry Location Set shall be formed by identifying all potential river entry locations.

(A4.1-2) Criteria for determining the completeness of the range of river entry locations to be included in the Candidate River Entry Location Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.



A.4.2 River/Groundwater Interface Description

The requirements in this section call for providing exposure models with valid information about aquatic habitat contaminant concentrations that occur in the ground near the Columbia River bottom. An example is salmon spawning areas (salmon redds) that can be impacted by groundwater contamination.

The river/groundwater interface is the zone between the bulk river water and the bulk groundwater where a spatial concentration gradient exists between the two bulk water bodies. In this zone the contaminant concentration is somewhere between the bulk river concentration (probably low) and the groundwater concentration, which may be unacceptably high. Aquatic biota depend on this zone. For example, salmon reproduction depends on viable conditions in this zone.

The requirements in this section also call for estimates of future contaminants to the Columbia River to be based on adequate estimates of the initial groundwater entry locations, contaminant flux (flow/unit cross sectional area) into the river, and mixing between groundwater and surface water.

Future viability of Columbia River habitat depends on contaminant influx from the Hanford Site. The requirements in this section are as follows:

(A4.2-1) The data, models, and parameters developed shall support the assessment of the exposures (see requirements in Section II-A.8) over the required period of time (see the "Principles and General Requirements" Section).

(A4.2-2) Models and data that represent the mixing of groundwater with surface water shall support the assessments related to the exposures and impact to aquatic species specified in Sections II-A.8 through II-A.9, for example, the effectiveness of salmon reproduction.

(A4.2-3) Future location and mass flux of contaminants into the Columbia River shall be evaluated.

(A4.2-4) Future contaminant concentrations near the river bottom shall be assessed, both in mixtures of groundwater and river water beneath the river bottom (pore water) and at the river bottom, where the pore water enters into the main body of river water.

(A4.2-5) Future contamination of other media and contaminant holdup in other media, such as sediment, which are in contact with groundwater and pore water shall be evaluated.

A.4.3 Groundwater Influx into the River

The requirements in this section call for determining the contaminant distribution in the Columbia River by identifying the initial entry location and the flux of contaminants into the river. Locating the influx of groundwater into the river and its intensity (volumetric flux) is needed to estimate the level of

mixing and concentration in the Columbia River. Concentrations are needed to calculate biological effects. Knowing the location of influx makes it possible to relate the contaminant concentration to specific habitat areas and human use locations. The requirements in this section are as follows:

(A4.3-1) To quantify the variety and amount of contaminants currently reaching the Columbia River, groundwater entering the river shall be characterized.

(A4.3-2) Measurements shall be coordinated with model development to describe mixing between groundwater and surface water over the transition zone between them.

(A4.3-3) Maps of groundwater influx into the Columbia River from contaminated regions of the Hanford Site shall be provided. Volumetric flux contours over the Hanford Reach shall be provided.

(A4.3-4) Semi-permanent shoreline groundwater access structures (that is, drive points) shall be established at various distances along the Hanford shoreline. The distance separating structure locations shall be determined by potential contaminant influx, within the following limits:

(a) Each river mile within the Hanford Site shall have a minimum of four structures. The structures shall be used to assess contaminant influx by sampling groundwater entering the Columbia River. More structures should be added in known zones of greater groundwater or contaminant influx.

(b) The interval between structures shall not exceed 0.8 kilometers (0.5 miles).

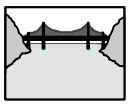
(c) The required intervals may be waived with agreement by the CRCIA Board.

(A4.3-5) Subsurface stratigraphy changes shall be noted during establishment of semi-permanent shoreline groundwater access structures, such as wells. This information will be valuable in estimating the hydraulic conductivity of the groundwater path at the sample location.

(A4.3-6) The amount of groundwater entering the Columbia River at each sampling location shall be estimated from the stratigraphy.

(A4.3-7) Groundwater sampling at the river shall be conducted to meet the following criteria:

(a) Pore water on the Hanford shoreline at 30-300 centimeters (1-10 feet) below the unconfined groundwater table elevation shall be analyzed throughout the entire Hanford Reach.



(b) Groundwater influx to the Columbia River shall be analyzed at the Hanford shoreline throughout the entire Hanford Reach.

(c) A pore water sampling plan shall be developed, including a standard suite of chemicals to be analyzed in addition to suspected contaminants.

(d) A groundwater sampling plan shall be developed, including a standard suite of chemicals to be analyzed, both radioactive and chemical contaminants, in addition to suspected contaminants and physical parameters.

(e) A stratigraphic section of soil samples shall be taken at each groundwater sampling location to correlate groundwater contaminant impact with the degree of soil impact at that given location.

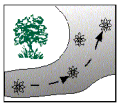
(f) Concentration gradients in the ground near the Columbia River bottom shall be measured.

(A4.3-8) The quantity of radioactive materials currently in the Columbia River shall be estimated by an aerial geophysical survey of the river and surrounding locations.

(a) Shoreline and island areas identified to have the highest relative radioactivity shall have ground level and/or benthic surveys.

(b) The geophysical survey of the Columbia River and surrounding locations shall be timed to coincide with the yearly low water cycle of the Columbia River to characterize the radioactive contamination with the effect of shielding minimized.

(A4.3-9) Benthic groundwater influx surveys shall be completed to provide input into the decision making process whereby the number of shoreline groundwater sampling structures per mile are considered. Areas of greater groundwater influx to the river shall have more sampling structures.



A.5 Fate and Transport of Columbia River-Borne Contaminants

The requirements in this section call for representing the way the contaminant distribution in the river evolves. The Columbia River redistributes contaminants to habitat where the contaminants may injure humans, ecosystems, and eventually cultures. It transports a large amount of water and a much smaller but significant amount of suspended solids (sediment). Some contaminants concentrate on the sediment particles, making them primary dose contributors in some situations.

Suspended sediment is continually settling, especially where flow rates are low. Sediment settles in holes and quiet water regions of the river, such as in sloughs and behind large rocks, providing a reconcentration mechanism. Sediment settled on the river bottom can also be resuspended and carried downstream. Dissolved contaminants are carried by the river without settling out. Contaminants that dissolve out of the sediment are carried with the river water.

As slowly flowing groundwater approaches the river channel, it passes through the river bottom into the main body of the river. Contaminant concentration varies as it approaches and passes through the river bottom. Lateral mixing into the main body of the river is slow and not complete for perhaps tens of miles below the point of introduction into the river. Higher contaminant concentrations, resulting from high groundwater concentrations, persist along river streamlines emanating from contaminated groundwater influx points, until the mixing with the less contaminated river water is complete. The concern is redistribution of contaminants to critical locations where they may contact humans, plants, and animals at concentrations and for periods of time that are harmful. Critical locations are defined in Section II-A.6. The following is an overview of the requirements in this section:

(A5.0-1) The fate assessment of river-borne contaminants (to include locations of sediment deposits) shall support exposure and dose assessment.

(A5.0-2) The transport assessment of river-borne contaminants shall support exposure and dose assessment.

(A5.0-3) Hot spots (contaminant concentrations) in the Columbia River that result from slow mixing of high concentration contamination sources with river water and suspended solids shall be assessed.

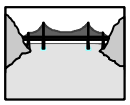
(A5.0-4) All Hanford contamination in the Columbia River environment that has the potential to contribute to habitat or drinking water contamination shall be identified.

A.5.1 Required Candidate River Holdup Location Set

The requirements in this section call for a Candidate River Holdup Location Set that identifies holdup regions with potential to contribute to contaminant sources in the River. The requirements in this section are as follows:

(A5.1-1) The Candidate River Holdup Location Set shall be formed by identifying contaminant holdup locations in the river with the potential to harm humans, cultures, or biota.

(A5.1-2) Criteria for the completeness of the holdup locations to be included in the Candidate River Holdup Location Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.



A.5.2 Contaminant Redistribution to Habitat

The requirements in this section call for adequately representing the way contaminants redistribute to habitat. Valid concentrations near the point where contaminated groundwater is introduced are required. An example is the habitat of bottom fish, such as sturgeon.

Contaminant concentration and accumulation at locations where they may contact humans, plants, and animals are the primary concerns when representing redistribution. The requirements in this section are as follows:

(A5.2-1) Groundwater mixing with surface water and flow representation shall support valid assessment of contact between receptors and contaminants in the Columbia River. An example is the exposure of bottom fish.

(A5.2-2) Hanford contamination that may have the potential to significantly affect the creation or mitigation of present or future critical locations (defined in Section II-A.6.3) in the Columbia River environment shall be identified.

(A5.2-3) Columbia River chemical and physical environment with the potential for precipitating out Hanford chemicals shall be identified.

(A5.2-4) Local contamination of drinking water in the study area shall be assessed.

(A5.2-5) Columbia River changes that affect habitat and species changes shall be identified for inclusion in the contaminant redistribution assessment.

(A5.2-6) Peak contaminant concentrations in habitat shall be assessed.

(A5.2-7) Biotic redistribution and concentration of contaminants in habitat shall be identified.

A.5.3 Contaminant Transport in the River

The requirements in this section call for representing the way that the contaminant distribution in the river evolves over potentially very long periods of time. The requirements address the dilution of groundwater contaminants with river water. Dilution of groundwater with river water substantially reduces the biological hazard, but it happens slowly. Influx from groundwater leaves the river bottom and mixes with bulk river water. Pore and interstitial water in the ground next to the river bottom is covered in Section II-A.4.

The requirements also address evaluation of contaminated solids in the river. The extent of contamination in sediment is many times that of the water with which the sediment comes to equilibrium. Contaminated sediment travels slowly down river over a very long period of time. The movement of both

initially contaminated solids and those accumulated at an intermediate location is covered. Also, mechanisms that cause accumulated contaminants to be transported by the Columbia River potentially create new hazards.

The effect of Hanford effluents from remediation and construction impacts need to be considered, for example, changes to contaminant mobility in response to in situ treatment of contaminated groundwater.

The requirements in this section also examine chemical and physical behavior of contaminants in the river. The physical and chemical properties of river water affect the impact of contaminants. Chemical reactions of contaminants in the river also affect the contaminants' impact. Some synergism of Hanford and offsite contaminants may occur in the river, causing a greater cumulative effect on river plant and animal life. The requirements in this section are as follows:

(A5.3-1) Contaminant dilution and reconcentration (contaminant concentration) shall be identified.

(A5.3-2) Non-uniform distribution of contaminants in the Columbia River shall be considered. Examples are near sources of contaminated groundwater and locations where contaminants concentrate or local inventories accumulate.

(A5.3-3) Hydrodynamic behavior that affects habitat contamination shall be represented. Examples are laminar flow and weak turbulence.

(A5.3-4) The interactions of multiple phases shall be identified. Examples are water solution, settled sediment, organic sediment, and suspended particulates in the water column.

(A5.3-5) Mapping of current contaminant inventories at intermediate locations within the study region shall be performed.

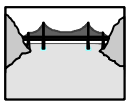
(A5.3-6) Future contaminant inventories at Columbia River locations, particularly in habitat, shall be identified.

(A5.3-7) Effects of natural phenomena (such as reduction of Columbia River water oxygen and pH as a result of organics decomposition) on Hanford contaminants shall be identified.

(A5.3-8) Physical changes in the Columbia River causing remobilization of contaminants shall be considered.

(A5.3-9) The effects of Columbia River water interaction with groundwater shall be identified. An example is the change in solubility of contaminants.

(A5.3-10) Annual and diurnal variations in river flow and conditions, such as temperature, salinity, and pH, shall be identified to establish limiting dose conditions. Effects on bank storage and upwelling and on influx shall be identified.



(A5.3-11) Interactions of seasonal peaks with biota shall be identified. An example is the effects of organic contaminants load on biological processes, such as birth.

(A5.3-12) Transport of contamination in the river shall be evaluated.

(A5.3-13) Biota-driven redistribution of contaminants (mixing and relocation) shall be identified.

(A5.3-14) The effects of dams, turbine repairs, or construction shall be identified.

(A5.3-15) Scouring of Columbia River banks during periods of high river flow shall be identified.

(A5.3-16) The effects of treated effluent discharged from Hanford remediation processes into the Columbia River shall be identified.

(A5.3-17) Effects of Hanford remedial actions on hydrological characteristics of the Columbia River shall be identified.

(A5.3-18) Interaction of Hanford contaminants with other materials in the river shall be identified. Examples are $Cr^{VI} \rightarrow Cr^{III}$; pH, etc., at the river.

(A5.3-19) The effects of contaminant chemical changes along the transport path, such as changes in the transport medium, shall be identified. An example is groundwater to river water.

(A5.3-20) Interaction of Hanford contaminants with offsite river impacts, such as agricultural sedimentation, shall be identified.

(A5.3-21) The effects of changes in the Columbia River from sources other than Hanford shall be identified when they contribute to Hanford-derived impacts. An example is additional non-Hanford pollutants interacting with Hanford contaminants.

(A5.3-22) The effects of river conditions on chemical mobility shall be identified.

(A5.3-23) Hanford thermal pollution shall be identified.

A.5.4 Contaminant Transport by Sediments in the River

The requirements in this section call for evaluating the movement of contaminants in and near the Columbia River by sediments. Contaminants are held up on sediments in much higher concentrations than in water. Contaminants can be moved down stream either by exchange between the sediment and flowing water or by sediment movement. The requirements in this section are as follows:

(A5.4-1) Transport of sediment by river water flow shall be explicitly represented.

(A5.4-2) Contaminant transport by moving sediments shall be evaluated.

(A5.4-3) The representation of contaminant transport and accumulation by sediment shall support valid assessment of habitat contamination.

(A5.4-4) Potential movement of disturbed sediment shall be evaluated. Hazards that could arise from sediment movement shall be identified.

(A5.4-5) Conditions leading to sediment resuspension shall be identified. Examples are the role of Hanford remediation activities on sediment resuspension and the effects of dredging.

A.5.5 Contaminant Deposition and Accumulation

The requirements in this section call for evaluating river-borne contamination deposited at intermediate locations along the path to the Pacific Ocean. These requirements are used in assessing habitat contamination and consequent receptor exposure and impacts. The contamination accumulates and has the potential to form large quantities of concentrated material that constitute new hazards. Contaminated sediment accumulates in low velocity regions of the river, including holes, which are significant for fish habitat. Suspended solids settle out of river water where flow is non-turbulent. Buried sediment in the environment also represents a hazard when it is resuspended and set into motion. The requirements in this section also address accumulation of contamination by plants and animals at the river, which also concentrate contaminants. The concern is limiting contaminant conditions that lead to the highest dose rates to plants, animals, and humans. The requirements in this section are as follows:

(A5.5-1) Contaminant reservoirs/sinks in the river shall be identified.

(A5.5-2) Initial contamination of sediment shall be evaluated.

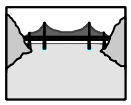
(A5.5-3) Present and future peak sediment concentrations shall be evaluated.

(A5.5-4) Contaminant accumulation and concentration by plants and algae at the Columbia River shall be identified.

(A5.5-5) Contaminated sediment accumulation in low velocity regions that are used as habitat shall be identified. Examples are fish habitat in regions behind large boulders, holes, sloughs, and large, down-stream pools.

(A5.5-6) Conditions affecting release of held-up contaminants shall be identified.

(A5.5-7) Conditions under which sediment or biota release contaminants to river water in response to physical or chemical river changes shall be identified.



(A5.5-8) Future accumulation of contamination in sediment near contamination currently buried in sediment shall be evaluated.

(A5.5-9) Opportunities for microscale sorbtion shall be identified.

(A5.5-10) Locations of contaminant accumulations shall be mapped.

(A5.5-11) Bathymetric maps shall be developed in regions of the river where sediment settling could potentially occur.

(A5.5-12) Short-term and long-term hazards from buried sediment shall be identified, for example, at McNary Pool.

A.6 Critical Habitat and Uptake Locations

The requirements in this section call for identifying candidate locations of plant life, animal life, and human usage where contaminants are likely to enter exposure pathway webs. These locations include habitats of both aquatic and river-dependent terrestrial life. The requirements also call for other critical locations, such as municipal water intakes, to be identified. The following is an overview of the requirements in this section:

(A6.0-1) Candidate habitat locations within the study area shall be identified.

(A6.0-2) Cleanup impact on critical locations shall be assessed. (See Section II-A.11.)

(A6.0-3) The spatial representation scheme shall support realistic representation of exposure to contaminants that occur at critical locations.

(A6.0-4) Any habitats within the study area that are considered high priority or sensitive by the State of Washington shall be accounted for. To be identified are habitats critical to the well being of plant and animal species that are classified as threatened, endangered, or sensitive by the State of Washington, the State of Oregon, the federal government, and/or the Indian Nations.

(A6.0-5) Suspect areas with unknown characteristics shall be identified.

(A6.0-6) All available sources of information shall be catalogued and included in databases to the extent needed to meet assessment objectives.

A.6.1 Required Candidate Habitat Location Set

The requirements in this section call for a Candidate Habitat Location Set that identifies habitat regions which potentially contribute to dose in biota and humans. The requirements in this section are as follows:

(A6.1-1) The Candidate Habitat Location Set shall identify all habitat with the potential to expose humans and biota to contaminants.

(A6.1-2) Criteria for determining the completeness of the range of habitat locations to be included in the Candidate Habitat Location Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A6.1-3) Locations of aquatic habitat regions shall be identified.

(A6.1-4) Locations of salmon redds nesting habitat, where juvenile impacts occur, shall be identified.

(A6.1-5) All available data shall be considered in establishing candidate habitat locations. In particular, sampling and analysis done by the State of Oregon and also work done by the Bi-State Water Quality Commission shall be considered.

(A6.1-6) Locations of geochemical and groundwater impacts stemming from cleanup actions shall be identified.

(A6.1-7) Bottom-feeding fish habitat locations shall be identified. An example is the habitat of sturgeon, a long-lived species.

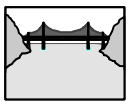
(A6.1-8) Habitat located near outfall pipes shall be identified.

(A6.1-9) Habitat located where groundwater enters the river shall be identified.

(A6.1-10) Bank storage, recharge, and discharge of groundwater near the river due to varying river levels shall be identified.

(A6.1-11) Locations on the Hanford Site that are related to Columbia River use shall be identified, including the Hanford reach as a whole, but particular noting the following:

- B Reactor (mile 384.1 - 383.9)
- K Reactor (mile 381.8 - 380.9)
- N Reactor (mile 379.4 - 378.5)
- islands: D Island (mile 376.9 - 376.5)
- H Reactor (mile 372.7 - 372.3)
- sturgeon habitat in river bottom holes near F reactor (mile 367.6 - 367.0)
- sloughs and backwaters: F Slough, H Slough, White Bluffs Slough, Hanford Slough (mile 372.7 - 372.3), below the Washington Public Power Supply system
- springs below Hanford town site (mile 372.7 - 372.3)



- known areas of past or present contaminant influx, or culturally or ecologically sensitive areas, such as
  - marshy areas: tules
  - 300 Area shore
  - outfalls
  - foods and medicines in riparian region

A.6.2 Required Candidate Habitat Features Set

The requirements in this section call for identifying the set of features associated with critical locations that are needed to characterize the conditions for contact between harmful contaminants and biota. The requirements in this section are as follows:

(A6.2-1) The Candidate Habitat Features Set shall identify Columbia River and land features needed to support realistic representation of contact between receptors and contaminants.

(A6.2-2) Criteria for the completeness of the range of habitat features to be included in the Candidate Habitat Features Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A6.2-3) Columbia River and land features that contribute to selected impacts shall be identified.

(A6.2-4) Land features that support evaluation of stream-side habitat shall be identified.

(A6.2-5) Salmon redds shall be characterized to support assessment of current and future impact to salmon reproduction.

(A6.2-6) Habitat for candidate species shall be identified, both as a receptor for contamination and as a supporting environment for the candidate receptors. (See Section II-A.7.)

A.7 Receptors and Exposure Pathways

The requirements in this section call for identifying candidate receptors from which the receptors of concern (the study set) will be selected (see Appendix II-B). The requirements in this section also call for defining the pathways through which receptor exposure potentially could occur. Examples of ways receptors may be exposed to contaminants include ingestion, inhalation, dermal exposure, or external radiation exposure.

The requirements in this section suggest some candidate receptors. Additional candidates will be identified when their criticality to other receptors is determined because of their essential position in the web of ecosystem relationships. The following is an overview of the requirements in this section:

(A7.0-1) An all-inclusive, internally consistent set of receptors shall be identified to include river-dependent humans, plants, animals, and groups whose activities bring them into contact with river corridor resources. These activities include, but are not limited to, sustenance, recreational, commercial, religious, and cultural practices. The term "receptor" also includes the culture of affected population groups (for example, the Yakama Indian Nation and Hispanic migrant farm workers) as well as the economic viability of commercial groups (for example, agriculture and river barge transportation). This requirement includes those candidate receptors who come into contact with river resources even though they may be a considerable distance from the river corridor under study. Examples include those coming into contact with commercially marketed fish, wide-ranging animals that drink at the river, water fowl, distributed municipal water, irrigation water, wind-blown sediments, and hydroelectric parts or equipment.

(A7.0-2) All interactions with river resources that may lead to contaminated habitat, food, or receptors and that contribute to exposure levels shall be identified.

(A7.0-3) All humans, animals, and plants that use habitat in the study area shall be considered as candidate receptors.

(A7.0-4) Pathway webs shall be developed that capture the relationships of the candidate receptors to river resources. Different relationship webs may be needed for each type of potential impact such as health effects, economic effects, and cultural practices. All such webs are expected to embody many of the river ecosystem relationships.

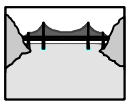
(A7.0-5) Intrusion scenarios that result in potential contaminant transport into the river corridor shall be identified for both humans and biota.

(A7.0-6) Exposure mechanisms related to airborne contaminants shall be identified for both humans and biota.

A.7.1 Required Candidate Receptors Set

The requirements in this section call for a Candidate Receptors Set that identifies the receptors which could potentially be the subjects of the impact assessment. The requirements in this section are as follows:

(A7.1-1) The Candidate Receptors Set shall include all species that could potentially be subjects of harm from Hanford contaminants at any time within the period covered by the assessment.



(A7.1-2) Criteria for determining the completeness of the range of species to be included in the Candidate Receptors Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A7.1-3) All species that enter into the representation of ecosytem structure and ecosystem dynamics shall be included in the Candidate Receptors Set.

(A7.1-4) All species that enter into the representation of ecosystem functions and services to stakeholders shall be included in the Candidate Receptors Set.

(A7.1-5) All new competing species that have been introduced in, or could spread into, the study area, particularly those that could affect ecosystem robustness and stability, shall be included in the Candidate Receptors Set.

(A7.1-6) All species that contribute to sustaining the existing trophic structure shall be included in the Candidate Receptors Set.

(A7.1-7) All species that compete with species included in the Candidate Receptors Set or that have the potential to alter the trophic structure by eliminating any included species shall also be included in the Candidate Receptors Set.

(A7.1-8) Particular attention shall be given to including all species at lower trophic levels in the Candidate Receptors Set to support assessment of biological contamination pathways. (See Section II-A.7.3.)

(A7.1-9) All species that entering into cultural dependency webs shall be included in the Candidate Receptors Set. (See Section II-A.7.4.)

(A7.1-10) All species that carry contaminants between the riparian region and the terrestrial zone on the Hanford Site shall be included in the Candidate Receptors Set.

(A7.1-11) All edible plants, or classes of edible plants, shall be included in the Candidate Receptors Set. Examples are asparagus, wild onions, mule deer, fish, and herons.

(A7.1-12) All biota or socio-economic entities introduced as “Receptors of Concern” in Section II-A.7.5 shall be included in the Candidate Receptors Set.

(A7.1-13) All game animals shall be included in the Candidate Receptors Set.

(A7.1-14) All species considered to be indicators of environmental quality shall be identified and included in the Candidate Receptors Set. An example is the presence or absence of freshwater mollusks, which may be an excellent indicator of river dynamics.

(A7.1-15) All species classified as threatened, endangered, candidate, or sensitive species by the states, federal agencies, or Indian Nations and that depend on the Columbia River for survival, directly or indirectly, shall be included in the Candidate Receptors Set. Examples are the Great Blue heron, Columbia River limpet, Columbia River pebble snail, and salmon.

(A7.1-16) Species that bioconcentrate contaminants and/or their effects and pass them on to their offspring shall be included in the Candidate Receptors Set.

A.7.1.1 Required Human Populations to be Included in the Candidate Receptors Set

The requirements in this section identify the human population categories affected by Hanford contaminants that are to be included in the Candidate Receptors Set. The populations are categorized by individual life styles that are shared by members of groups with a common cultural affinity. The requirements in this section are as follows:

(A7.1.1-1) The most impacted human populations that can be identified shall be included in the Candidate Receptors Set.

(A7.1.1-2) The human populations needed to evaluate equity and fractional impact to (the most impacted) groups shall be included in the Candidate Receptors Set.

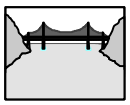
(A7.1.1-3) The following populations shall be included in the Candidate Receptors Set:

(a) Tri-Cities residents
(b) agricultural residents
(c) wildlife refuge and wild and scenic river rangers
(d) hunters and fishers
(e) recreational users
(f) industrial workers
(g) fish hatchery workers

(A7.1.1-4) The following Native American populations shall be included in the Candidate Receptors Set:

(a) subsistence residents living a traditional life style (unrestricted use)
(b) hunter/gatherers
(c) cultural activities visitors
(d) Columbia River island users

(A7.1.1-5) Populations, in some cases related to cultural affinity, which depend on the Columbia River shall be included in the Candidate Receptors Set. An example is Southeast Asians with their fish-oriented culture.



A.7.2 Required Candidate Exposure Mechanisms Set

The requirements in this section call for a Candidate Exposure Mechanisms Set that identifies all the exposure mechanisms which result in contact between harmful contaminants and receptors. The requirements in this section are as follows:

(A7.2-1) The Candidate Exposure Mechanisms Set shall include all the exposure mechanisms that potentially result in contact between harmful contaminants and receptors.

(A7.2-2) Criteria for determining the completeness of the range of exposure mechanisms to be included in the Candidate Exposure Mechanisms Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A7.2-3) All forms of proximity or contact leading to ingestion, inhalation, dermal exposure, or external radiation exposure shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-4) Exposure mechanisms resulting in uptake of contaminants by contaminated humans, plants, and animals transporting contaminants offsite shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-5) Exposure mechanisms associated with collecting, eating, and using edible plants and medicines shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-6) Exposure mechanisms resulting in uptake of contaminants by threatened, endangered, candidate, and sensitive species shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-7) Exposure mechanisms that result in uptake of contaminants by game animals shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-8) Exposure mechanisms that result in uptake of contaminants by indictor species shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-9) Exposure mechanisms that involve contact between receptors and contaminants transported by intruders to the Columbia River species shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-10) Exposure mechanisms associated with inhalation of volatized contaminants, including aerosols, shall be included in the Candidate Exposure Mechanisms Set.

(A7.2-11) Inhalation of surface contamination shall be included in the Candidate Exposure Mechanisms Set.

A.7.3 Required Candidate Pathways Set

The requirements in this section call for a Candidate Pathways Set that identifies and defines all the networks of biological interactions which result in transfer of harmful contaminants between receptors. The requirements in this section are as follows:

(A7.3-1) The Candidate Pathways Set shall be formed by including all biological interactions that result in transfer of harmful contaminants between receptors.

(A7.3-2) Criteria for determining the completeness of the range of pathways to be included in the Candidate Pathways Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A7.3-3) Direct human exposure pathways shall be included in the Candidate Pathways Set.

(A7.3-4) Food web pathways accounting for indirect human exposure shall be included in the Candidate Pathways Set. Examples are transmission of hazardous materials to humans from contaminated fish and game.

(A7.3-5) Hazardous materials transmission from prey to predator shall be included in the Candidate Pathways Set.

(A7.3-6) Hazardous materials transmission from environmental media to plants shall be included in the Candidate Pathways Set.

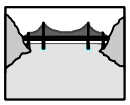
(A7.3-7) Pathway/dose analysis shall not be over generalized by dependency on surrogate equivalency assumptions.

A.7.4 Required Candidate Cultural Dependency Webs

The requirements in this section call for a Candidate Cultural Dependency Webs Set that identifies and defines all the networks of entities and dependencies which result in damage to cultural practices and institutions. The requirements in this section are as follows:

(A7.4-1) The Candidate Cultural Dependency Webs Set shall be formed by including all dependency webs that result in damage to cultural practices and institutions.

(A7.4-2) Criteria for determining the completeness of the range of cultural dependency webs to be included in the Candidate Cultural Dependency Webs Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.



(A7.4-3) Cultural dependency webs associated with minority cultures located in the vicinity of the study area shall be defined and included in the Candidate Cultural Dependency Webs Set. Examples are cultures of Native American Nations and Hispanic farm workers.

(A7.4-4) Hanford-related contamination that affects Native American cultures, in particular the cultures of the Nez Perce, Umatilla and Yakama tribes, shall be incorporated in the appropriate cultural dependency webs. Contamination of the following shall be included:

(a) contamination of ceremonial and religious areas

(b) contamination of artifacts

(c) contamination of traditional foods and medicines

(d) role of Hanford contaminants in the degradation or destruction of the Columbia River ecosystem

(A7.4-5) Dependency webs for agriculture and tourism shall be defined and included in the Candidate Cultural Dependency Webs Set.

(A7.4-6) Probable cultural and life style changes shall be considered as they alter pathways and cultural dependency webs.

A.7.5 Required Receptors of Concern Set

The requirements in this section call for assembling receptors of concern to stakeholders in a Receptors of Concern Set. Inclusion of this set in the Candidate Receptors Set is required. The requirements in this section are as follows:

(A7.5-1) The Receptors of Concern Set shall include all species of concern to Hanford Stakeholders.

(A7.5-2) Criteria for determining the completeness of the range of species to be included in the Receptors of Concern Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A7.5-3) Species of cultural importance to minority cultures shall be included in the Receptors of Concern Set.

A.7.6 Required Quantification of Human Exposures

The requirements in this section call for identifying and considering the factors that influence human exposures when quantifying them. The requirements in this section are as follows:

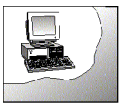
(A7.6-1) Evaluation of the Native American subsistence scenario shall include the following effects:

(a) differential patterns of consumption, especially consumption of natural foods and medicines, plus additional exposures due to cultural practices

(b) differences in sensitivity due to age, gender, activity clusters, physiology, and background nutritional factors

(A7.6-2) Social activities that focus on the Columbia River and its resources or environs shall be considered.

(A7.6-3) Native American religious activities that focus on the Columbia River, its resources, and its sacred geography that are vulnerable to Hanford contaminants shall be included in exposure quantification. These activities shall be defined only as permitted and approved through tribal consultation.



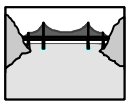
A.8 Dose Assessment

The requirements in this section call for evaluating the dose that results from potential exposure of the receptors to Hanford-derived contaminants. Dose in individual biota is defined as the presence over time of toxicant concentrations or energy deposition rates in the tissues of a selected receptor. The dose characterization needed varies with receptor role. If a particular biota category is of interest only as a contaminant carrier, simple mass uptake adequately characterizes dose. However, additional properties are needed to define the impact resulting from that dose. Contaminant uptake events that affect economic or socio-cultural groups shall be identified.

Doses from current exposures can be obtained by sampling environmental media or biota, as well as by modeling. Future doses must be estimated based on exposure models. In the absence of applicable historical measurements, past doses must also be estimated using exposure models. The following is an overview of the requirements in this section:

(A8.0-1) Dose measures and attributes identified shall be sufficient to correlate with all candidate impacts identified in Section II-A.9.

(A8.0-2) Dose transfer or uptake effectiveness for the activities included in the exposure scenarios defined in Section II-A.7 shall be defined for each receptor group having different activities in relationship to river resources and potential exposure. Examples include contacted contaminant mass taken up and bioaccumulation in the different scenarios for fishery and related river workers, farm workers where irrigation water is used, Native Americans, Tri-Cities residents, and metropolitan area industrial and office workers.



A.8.1 Required Candidate Dose Measures Set

The requirements in this section call for a Candidate Dose Measures Set that identifies all the dose measures which might be needed to provide a basis for impact quantification. The requirements in this section are as follows:

(A8.1-1) The Candidate Dose Measures Set shall be formed by including all dose measures that might be needed to provide an basis for impact quantification.

(A8.1-2) Criteria for determining the completeness of the range of dose measures to be included in the Candidate Dose Measures Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A8.1-3) Dose measures in the Candidate Dose Measures Set shall support assessment of the impacts and tolerance (vitality) identified in the "Candidate Impacts Set" required in Section II-A.9.1.

(A8.1-4) Measures of short-term, acute exposures and long-term, chronic exposures of receptors to hazardous contaminants shall be included in the Candidate Dose Measures Set.

(A8.1-5) Dose measures shall support characterization of the effects of dose duration/intensity, including multi-generational doses, and shall support correlation with impacts included in the Candidate Impact Set.

(A8.1-6) Dose measures that support evaluation of combined and synergistic effects of multiple contaminants, including background and exposures from non-Hanford sources, shall be included in the Candidate Dose Measures Set.

(A8.1-7) Measures of chemical concentration in body tissue shall be included in the Candidate Dose Measures Set.

A.8.2 Required Candidate Dose Attributes Set

The requirements in this section call for a Candidate Dose Attributes Set that identifies all the dose attributes which could be needed to provide a basis for impact quantification. The requirements in this section are as follows:

(A8.2-1) The Candidate Dose Attributes Set shall be formed by including all dose attributes that might be needed to provide a basis for impact quantification.

(A8.2-2) Criteria for determining the completeness of the range of dose attributes to be included in the Candidate Dose Attributes Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A8.2-3) Association of dose measures with body organs shall be specified in the Candidate Dose Attributes Set.

(A8.2-4) The statistical properties of dose relevant to assessing dose to a given, most exposed fraction of a population shall be identified and included in the Candidate Dose Attributes Set in consultation with the CRCIA Board and shall be subject to its approval.

A.8.3 Required Quantification of Relationships Between Exposure and Doses

The requirements in this section call for identifying parameters in the relationships between exposure and doses. The requirements in this section are as follows:

(A8.3-1) Age and gender shall be considered in establishing humans absorption or uptake efficiency.

(A8.3-2) Small gene pools shall be included in relations between long term, cumulative exposures and doses. Examples are small Native American tribal gene pools and salmon gene pools.

A.9 Receptor Impact and Tolerance Assessment

The requirements in this section call for assessing adverse effects, based on the doses required in Section II-A.8. Both current and future effects from Hanford-derived contaminants will be assessed. The following is an overview of the requirements in this section:

(A9.0-1) Acute health effects shall be assessed. An example is subchronic effects from various exposures at fluctuating seasonal or peak exposure conditions.

(A9.0-2) Chronic health effects including delayed health effects and cumulative effects from long-term, including multi-generational, doses shall be assessed.

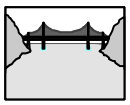
(A9.0-3) The full range of genetic effects shall be assessed in all affected populations.

(A9.0-4) The impact to community, tribal, and other populations' quality of life shall be assessed. This includes impact to jobs, housing, produce markets, and recreational opportunities.

(A9.0-5) The impact to tribal quality of life shall be assessed and include, but not be limited to, the following:

(a) restrictions on access to ancestral lands and heritage resources

(b) interruption of transfer of educational and spiritual knowledge within the community and between generations



(c) damage to cultural and religious values and sacred landscapes

(d) culturally important sites and resources lost/restored within the study area

(e) loss of sustainability for economic and environmental practices

(f) lost/gained access to open spaces

(g) visual and aesthetic impact to landscape

(h) lost/gained trust in governing institutions

(i) cost of avoiding exposure and illness

(A9.0-6) Impact measures that quantify all impacts assessed shall be established in consultation with the CRCIA Board and shall be subject to its approval.

A.9.1 Required Candidate Impact Set

The requirements in this section call for a Candidate Impact Set that identifies all of the known impacts which could be related to Hanford contaminants. The requirements in this section are as follows:

(A9.1-1) The Candidate Impact Set shall be formed by including all of the known impacts that may be related to Hanford contaminants of concern.

(A9.1-2) Criteria for determining the completeness of the range of impacts to be included in the Candidate Impact Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

(A9.1-3) Dependencies between impacts shall be documented in the Candidate Impact Set.

A.9.1.1 Environmental Impacts to be Included

The requirements in this section call for identifying and including environmental impacts in the Candidate Impact Set. The requirements in this section are as follows:

(A9.1.1-1) Direct harm to the ecosystem and damage to ecosystem robustness, resiliency, viability, and sustainability shall be included in the Candidate Impact Set.

(A9.1.1-2) Impacts of exposures on populations in terms of growth, maintenance, and reproduction shall be included in the Candidate Impact Set.

(A9.1.1-3) Impacts of Hanford contaminants on endangered species and migratory birds shall be included in the Candidate Impact Set.

(A9.1.1-4) Impacts on the ability of the ecosystem to support cultures without damage to itself shall be included in the Candidate Impact Set.

(A9.1.1-5) Direct mortality in animal populations shall be included in the Candidate Impact Set.

(A9.1.1-6) Ecotoxicity to individual members of key species exposed through a food web shall be included in the Candidate Impact Set.

(A9.1.1-7) Reversible and irreversible damage to species shall be included in the Candidate Impact Set. An example of irreversible harm is mutagenic effects on salmon.

(A9.1.1-8) Impacts on population size in animal species shall be included in the Candidate Impact Set.

(A9.1.1-9) Cumulative impacts to a species from multi-generational exposures shall be included in the Candidate Impact Set.

(A9.1.1-10) Damage at levels that could potentially impact the gene pool of any species shall be included in the Candidate Impact Set.

(A9.1.1-11) Loss or restoration of all species population stability shall be included in the Candidate Impact Set.

(A9.1.1-12) Loss of reproductive effectiveness shall be included in the Candidate Impact Set.

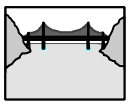
(A9.1.1-13) Effects from genetic changes shall be included in the Candidate Impact Set.

(A9.1.1-14) Changes to locally threatened species population or viability from competition between species shall be included in the Candidate Impact Set. An example is locally threatened bottom fish species.

(A9.1.1-15) Impacts of contaminants on competition between species shall be included in the Candidate Impact Set. An example is competition between pike and salmon.

A.9.1.2 Impacts on Humans to be Included

The requirements in this section call for identifying and including impacts on humans in the Candidate Impact Set. The requirements in this section are as follows:



(A9.1.2-1) All adverse effects at the individual level and over multiple generations shall be included in the Candidate Impact Set.

(A9.1.2-2) All adverse effects from actions to avoid exposure shall be included in the Candidate Impact Set.

(A9.1.2-3) All impacts from enforced cultural changes shall be included in the Candidate Impact Set.

(A9.1.2-4) All known effects on humans that could occur over the time period of the assessment shall be included in the Candidate Impact Set.

(A9.1.2-5) Impacts of concern to vulnerable populations shall be included in the Candidate Impact Set.

(A9.1.2-6) Cancer risk to populations over the duration of contamination shall be included in the Candidate Impact Set.

(A9.1.2-7) Mutagenic and clastogenic effects on humans shall be included in the Candidate Impact Set.

(A9.1.2-8) Overt teratogenic effects on humans due to structural or chromosomal factors, as well as fetal loss and spontaneous abortion, shall be included in the Candidate Impact Set.

(A9.1.2-9) Developmental effects on humans shall be included in the Candidate Impact Set. Examples are failure to thrive, developmental delays, and learning and behavioral deficits.

(A9.1.2-10) Reduced human birth rates and weights shall be included in the Candidate Impact Set.

(A9.1.2-11) Specific effects on human organ systems shall be included in the Candidate Impact Set. Examples are neurological, immunological, and metabolic effects.

(A9.1.2-12) Neuro-behavioral effects on humans shall be included in the Candidate Impact Set. Examples are peripheral neuropathy, effects on memory and cognition, biochemical neurotransmitter alterations that affect psychological function, and direct neurotoxicity.

(A9.1.2-13) The freedom of individuals to use the Columbia River without a resulting health impact shall be included in the Candidate Impact Set.

(A9.1.2-14) Impacts on community well-being and community health shall be included in the Candidate Impact Set.

(A9.1.2-15) Impacts to intra- and inter-generational equity shall be included in the Candidate Impact Set, including the following:

(a) effects on groups at highest risk due to exposure and/or sensitivity

(b) disproportional impacts on human and environmental health of minority and low income, such as social and economic impact

(c) monitoring and surveillance burdens for present and future generations

(A9.1.2-16) Impacts of current and future conditions on land use options shall be included in the Candidate Impact Set.

(A9.1.2-17) Impacts on degradation of values shall be included in the Candidate Impact Set.

(A9.1.2-18) Impacts on usability of resources on and adjacent to the Hanford Site shall be included in the Candidate Impact Set.

(A9.1.2-19) Impacts to a people from the availability of an individual species that they depend on shall be included in the Candidate Impact Set.

(A9.1.2-20) All the impacts on land development shall be included in the Candidate Impact Set.

(A9.1.2-21) All the impacts on recreation services and tourism shall be included in the Candidate Impact Set.

(A9.1.2-22) Costs of non-involvement or counter-involvement by affected people shall be included in the Candidate Impact Set.

A.9.1.3 Impacts on Native American Traditional Culture and Values to be Included

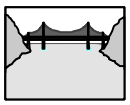
The requirements in this section call for identifying impacts on Native American traditional culture and values and including them in the Candidate Impact Set. The requirements in this section are as follows:

(A9.1.3-1) Dependencies between health impacts and cultural impacts on individuals practicing a Native American life style shall be documented in the Candidate Impact Set.

(A9.1.3-2) Lost use of resources critical to Native American cultures shall be included in the Candidate Impact Set. An example is lost use due to contamination hazards.

(A9.1.3-3) Lost access to resources critical to Native American cultures of shall be included in the Candidate Impact Set. An example is administrative restrictions.

(A9.1.3-4) Cultural harm, particularly the following aspects, shall be included in the Candidate Impact Set:



(a) loss of cultural viability/continuity
(b) loss of traditions
(c) loss of language
(d) loss of traditional religion
(e) loss of traditional disciplines and values
(f) loss of access to teaching sites, with consequent loss of teaching opportunities
(g) loss of use of traditional materials, with consequent loss of traditional activities

A.10 Assessment Scenarios: Columbia River, Climate, Geological, and Political Changes

Sections II-A.1 through A.9 define requirements to comprehensively assess potentially adverse effects of Hanford-derived contaminants in the Columbia River. These requirements are to be applied to current or normal conditions and hypothetical, but probable or credible, scenarios.

The requirements in this section specify the development of candidate scenarios that span all possibilities. Appendix II-B provides the requirements for winnowing these candidates to the most credible study set for the given budget and time limitations.

The "base case" scenario assumed in the preceding sections is defined by parameters that change either very slowly or inconsequentially and constitute present-day expectations. While the preceding sections are based on a normal scenario, future scenarios shall also be considered. Because all the possible combinations of scenarios would lead to an unworkable number of assessment cases, the number of scenarios must be limited. The set of scenarios to be included in the assessment includes those involving the largest impact of Hanford contaminants to the Columbia River. The following is an overview of the requirements in this section:

(A10.0-1) A set of scenarios that depict the maximum credible impact from Hanford shall be defined.

(A10.0-2) Credible scenarios with parameters that depict increased consequences from Hanford contaminants shall be identified to establish a set of scenarios for use in a comprehensive assessment.

(A10.0-3) The limited set of scenarios to be evaluated shall include waste containment performance corresponding to the current Hanford Site disposition baseline for cleanup. (See Section II-A.11.)

(A10.0-4) The set of scenarios to be evaluated include potential demographic changes for the river corridor area under study.

(A10.0-5) Scenarios to be assessed shall include, but not be limited to, the following:

(a) Scenarios that depict the groundwater recharge rate in a way that the maximum credible impact from Hanford is assessed. Examples are climate change, future site uses including irrigated agriculture, and river channel changes.

(b) Scenarios that depict contaminant dilution by groundwater or Columbia River water in a way that the maximum impact from Hanford is assessed. Examples are flood and drought scenarios, upgradient injection or extraction, disposition of present or new dams, and geologic events.

(c) Scenarios that depict enhanced remobilization of sediment in a way that the maximum impact from Hanford is assessed. Examples are future dredging, disposition of present or new dams, and river channel changes.

(d) Scenarios that depict potential changes in receptors. Examples are future Hanford land-use scenarios, Hanford Site accident scenarios, transportation accident scenarios, demographic scenarios, economic scenarios, institutional evolution scenarios, and cultural evolution scenarios.

(A10.0-6) Scenarios to be identified shall include, but not be limited to, the following:

(a) scenarios involving increased inventories of dangerous materials at Hanford, such as a projected future plutonium repository

(b) scenarios depicting the impact of newly introduced foreign species, such as the introduction of Northern Pike

(c) scenarios depicting loss of institutional control over the Hanford Site after various time periods; the full range of probable times for loss of institutional control shall be evaluated.

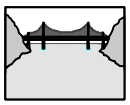
(d) scenarios depicting loss of cleanup funding

(e) scenarios depicting the future production of radionuclides and other new missions for the Hanford Site

(f) scenarios depicting ecosystem changes

A.10.1 Required Candidate Scenarios Set

The requirements in this section call for a Candidate Scenarios Set that identifies all the scenarios of potential concern. The requirements in this section are as follows:



(A10.1-1) The Candidate Scenarios Set shall be formed by including all the scenarios of potential concern.

(A10.1-2) Criteria for completeness of the range of scenarios to be included in the Candidate Scenarios Set shall be established in consultation with the CRCIA Board and shall be subject to its approval.

A.11 Hanford Site Disposition Baseline

The requirements in this section call for the Columbia River impact assessment to be consistent with the current definition of the Hanford Site after all cleanup and waste disposal actions are complete. Because this may be a very long period of time, an assessment is also needed for the transition period when operations are in process. Tools developed for this end-state analysis should also be useful in evaluating remediation alternatives.

As the strategic planning changes that defines the Hanford Site post-operations end state, the assessment shall be updated. The following is an overview of the requirements in this section:

(A11.0-1) A complete disposition baseline shall be documented for the assessment.

(A11.0-2) The assessment shall be consistent with the current revisions of the Hanford disposition baseline.

(A11.0-3) The impact from actual and proposed remedial actions shall be assessed for compatibility with target, end-state conditions.

(A11.0-4) The retrieveability of new waste forms that are part of either interim or permanent remedies and that affect the Columbia River shall be assessed.

(A11.0-5) Corresponding end-state conditions shall be identified for each item in the Candidate Inventories Set.

(A11.0-6) End-state conditions, including disposal forms, shall be defined sufficiently to enable risk evaluation.