4.1.2.2.6 Dermal Pathway: Exposure to Contaminants in Surface Water. The magnitude of an individual's dermal exposure to contaminants in surface water depends on whether it is never immersed, seldom immersed, frequently immersed, or always immersed in the river (Table 4.12). Because seeps and springs at the river shoreline are small and few in number, terrestrial species' dermal exposure to contaminants in water likely comes mostly from the river. Nonetheless, because contaminant concentrations in river water are generally much less than in seeps and springs and groundwater, 100 percent of terrestrial animals' dermal exposure to contaminants in water will be estimated in the screening assessment of ecological risk (see Section 4.2) using contaminant data from seeps and springs where such data are available. For example, species whose life style is completely aquatic, such as aquatic vegetation, benthic invertebrates, and fish, received a score of 4 for dermal exposure to surface water. For the purpose of scoring fully aquatic species, dermal exposure to surface water also includes exposure via respiration of water. Therefore, exposure via respiration of water by fully aquatic species was not addressed under the inhalation pathway, the subject of Section 4.1.2.2.7. Species that are semi-aquatic, such as the piscivorous birds and some of the mammals, received a score of 2. Species that are terrestrial and are seldom immersed in the river, such as the red-winged blackbird, bald eagle, and mule deer, received a score of 1. Terrestrial species that are virtually never in the river, such as mice, northern harrier, American kestrel, and owls, received a score of 0.

Table 4.12. Scoring Scheme for Tier I Species' Dermal Exposure to Contaminants in Surface Water

Frequency of Immersion in River Water			
Never	**Seldom**	**Frequently**	**Always**
0	1	2	4

In general, the primary mechanism of contaminant uptake for many fully aquatic species is via direct uptake across permeable membranes such as gill structures (addressed under dermal uptake in this section and Section 4.1.2.2.5). This can occur as a passive transfer or an active biological process (osmoregulation). Prey consumption (Section 4.1.2.2.2), incidental ingestion of sediment and pore water/groundwater during prey consumption (Section 4.1.2.2.3), and incidental ingestion of surface water during prey consumption (Section 4.1.2.2.4) are probably secondary uptake mechanisms.

4.1.2.2.7 Inhalation Pathway: Exposure to Contaminants in Air. Because the source of airborne contaminants in the study area is soil or surface water, the magnitude of an individual's inhalation exposure is a function of the amount of time the individual is close to these media. For example, species that spend most of their time within 0.5 meter (1.6 feet) (an arbitrary distance) of surface water received a higher score than those that spend most of their time more than 1.0 meter (3.3 feet) (also an arbitrary distance) from surface water (Table 4.13). Ground-nesting birds that forage on the water or ground, such as Canada geese and dabbling ducks (primarily herbivorous), received a score of 3 for inhalation exposure. Birds that

Table 4.13. Scoring Scheme for Tier I Species' Inhalation Exposure to Contaminants in Air

Distance above the Surface (meters)		
Mostly > 1.0 m	**Mostly < 1.0 m**	**Always < 0.5 m**
1	2	3

forage on the water or ground but nest in trees, such as the great blue heron and red-winged blackbird, received a score of 2. Birds that occasionally forage on the water or ground and nest in trees, such as the raptors, received a score of 1. Completely aquatic species, such as macrophytes, benthic invertebrates, and fish, respire water and thus received a score of 0 for inhalation of airborne contaminants. Respiration of water-borne contaminants by fully aquatic species was scored under dermal exposure to surface water (see Section 4.1.2.2.6).

4.1.2.2.8 Media Weighting. As noted in Table 4.4, media contamination varies between source areas. A weighting scheme was devised to account for this variation by scoring media according to their level of contamination at the two types of source areas, effluent pipe system and in-river. In-river source areas include deep holes, McNary Pool, near-shore areas, sloughs, and seeps/springs (see Table 4.4). Scores consist of 0 (little or no contaminant burden), 1 (moderate contaminant burden), and 2 (high contaminant burden).

For the in-river source areas, most of the contaminant burden is associated with in-flowing contaminated groundwater, pore water, and sediment. The high volume and flow rate of the Columbia River rapidly dilutes water-borne contaminants to well below groundwater levels, so surface water has lower concentrations of contaminants than groundwater, pore water, and sediment (Dirkes and Hanf 1996). The air contaminant burden is thus very low for in-river source areas. In contrast, surface soil, not groundwater, is the primary contaminated medium at the effluent source areas. Air, therefore, received a score of 2 at the effluent pipe system and 0 at the in-river source areas. Many aquatic and terrestrial prey species are likely to contact contaminants at the effluent pipe system and in-river areas (for example, in prey, sediment, soil, groundwater, pore water, surface water, air). Thus, prey received a score of 2 for both areas. Sediment and soil serve as a sink for contaminants at both the in-river and effluent pipe system areas, respectively, and thus received a score of 2 for both. Groundwater/pore water received a score of 1 at the effluent pipe system areas and a score of 2 at the in-river areas. Although contaminants enter surface water directly from the effluent pipe system and in-river areas, water-borne contaminants are highly diluted by the river. Thus, surface water received a score of 1 for both of these source areas (Table 4.14).

4.1.2.2.9 Exposure Duration. The magnitude of an individual's exposure to contaminants also depends on exposure duration. Because there is neither specific information on where migratory species go after they leave the study area nor information on what the contaminants they might be exposed to, residence time in the study area is the only indicator of exposure duration available for this species screen. Exposure duration scores were scaled to cover the same range as the other exposure scores (Table 4.15).

Table 4.14. Media Weighting Reflecting Relative Levels of Contamination at Effluent Pipe System Structure and In-River Source Areas (see also Table 4.4)

Contaminant Source Areas	Media				
	Air	**Prey**	**Sediment/Soil**	**Groundwater/ Pore Water**	**Surface Water**
Effluent Pipe System	2	2	2	1	1
In-River	0	2	2	2	1

Table 4.15. Scoring Scheme for Exposure Duration

Residence Time in Study Area		
Only Briefly in Study Area	**In Study Area 1 or 2 Seasons**	**Lifetime Resident of Study Area**
1	2	4

Species that migrate through the study area received a score of 1. Species that migrate but remain in the area for one or two seasons received a score of 2. Species that reside in the study area year-round received a score of 4.

4.1.2.2.10 Acute Radiation Sensitivity. Acute radiation sensitivity scores were scaled from 1-4 to cover the same range as the scores for exposure to biotic media (Section 4.1.2.2.2), abiotic media (Sections 4.1.2.2.3-4.1.2.2.7), and exposure duration (Section 4.1.2.2.9). Because 11 of the 23 contaminants of concern are radionuclides (see Section 2.0), acute radiation sensitivity was used as the basis for scoring species. Acute radiation sensitivity is not believed to be an *a priori* risk driver and is used here only to select species. In the screening assessment of ecological risk (see Section 4.2), potential risk to species was evaluated on a contaminant-by-contaminant basis using all 23 contaminants and considering both radiological and chemical toxicities. Because too little information was available on the sensitivity of all Tier I species to these individual radionuclides, species were put into broad groups. These groups were scored based on LD_{50} thresholds for acute radiation exposure (Whicker and Schultz 1982; Sparrow et al. 1967). For example, lower plants received the lowest score, and mammals and birds received the highest score because they are the most sensitive to radiation exposure (Table 4.16). (Note: This method was used to screen species, not to assess risk.)

Table 4.16. Scoring Scheme for Acute Exposure to Radiation (scores based on LD_{50} for radiation exposure)

Lower Plants	Higher Plants/Insects	Amphibians/Fish/ Reptiles	Birds/ Mammals
1	2	3	4

4.1.2.2.11 Summary of Scores. The scores (qualitative, relative exposure of species within taxonomic groups) for each species' exposure to media, exposure duration, sensitivity to radiation, and the media weightings were summarized as follows in Table C.3 (Appendix I-C):

1. Scores of abiotic ingestion exposure to sediment/soil (row 5), groundwater/pore water (row 6), and surface water (row 7) were summed and added separately to scores of biotic ingestion exposure to biomagnifying contaminants in prey (row 3) and non-biomagnifying contaminants in prey (row 4). This provided summary scores indicating ingestion exposure to biomagnifying contaminants (row 1) and non-biomagnifying contaminants (row 2) in all media with all media treated equally.

2. Scores of dermal exposure to sediment/soil (row 9), groundwater/pore water (row 10), and surface water (row 11) were summed. This provided summary scores (row 8) indicating dermal exposure to contaminants in all media with all media treated equally.

3. Inhalation scores (row 12) and dermal summary scores (row 8) were summed and added separately to ingestion summary scores for biomagnifying contaminants (row 1) and non-biomagnifying contaminants (row 2). This provided summary scores indicating overall exposure to biomagnifying contaminants (row 13) and non-biomagnifying contaminants (row 14) in all media, with all media treated equally.

4. Media weightings for the effluent pipe system and in-river source areas (see Table 4.14) were multiplied with scores of abiotic ingestion exposure to sediment/soil (row 5), groundwater/pore water (row 6), and surface water (row 7); with scores of dermal exposure to sediment/soil (row 9), groundwater/pore water (row 10), and surface water (row 11); with scores of inhalation exposure (row 12); and with scores of biotic ingestion exposure to biomagnifying contaminants in prey (row 3) and non-biomagnifying contaminants in prey (row 4). These products were summed separately for biomagnifying contaminants and non-biomagnifying contaminants. This provided summary scores indicating overall exposure to biomagnifying contaminants and non-biomagnifying contaminants at the in-river (rows 16 and 17) and effluent pipe system (rows 20 and 21) source areas.

5. Species were rank-ordered within major taxonomic groups (rows 18 and 19) based on summary scores of overall exposure to biomagnifying and non-biomagnifying contaminants at the in-river source areas (rows 16 and 17). Species were rank-ordered within major taxonomic groups (rows 22 and 23) based on summary scores of overall exposure to biomagnifying and non-biomagnifying contaminants at the source area for the effluent pipe system (rows 20 and 21).

6. The rank order of species was very similar between the in-river biomagnifier and biomagnifier scenarios for the effluent pipe system (rows 18 and 22). The rank order of species was very similar between the in-river non-biomagnifier and non-biomagnifier scenarios for the effluent pipe system (rows 19 and 23). Consequently, in-river biomagnifier summary scores (row 16) and biomagnifier summary scores for the effluent pipe system (row 20) were averaged (row 24). Likewise, in-river non-biomagnifier summary scores (row 17) and non-biomagnifier summary scores for the effluent pipe system (row 21) were averaged (row 25).

7. Species were rank-ordered within major taxonomic groups (rows 26 and 27) based on average biomagnifier summary scores (row 24) and average non-biomagnifier summary scores (row 25). The maximum of these two ranks was selected (row 28). The maximum rank provided an indication of relative exposure among species within taxonomic groups.

8. The highest of the average biomagnifier summary scores (row 24) and average non-biomagnifier summary scores (row 25) was selected. Because the highest average summary scores ranged up to 61 (see tule under emergent vegetation, row 24), it was necessary to re-scale by dividing these by 15 so that the composite effects scores would have approximately the same weight as the exposure duration and acute radiation sensitivity scores. The result was then added to the acute radiation sensitivity scores (row 30) and exposure duration scores (row 32) to produce composite scores (row 34). Species were also ordered by rank within major taxonomic groups (row 35) based on these composite scores (row 34).

The acute radiation sensitivity scoring did not differentiate species within taxonomic groups. Scoring these groups on the basis of other toxicological thresholds, such as the lowest observed adverse effects level or no observed adverse effects level, would not change the relative exposure of species within taxonomic groups as determined by the scoring using LD_{50} thresholds. However, it did emphasize that representatives of major taxonomic groups should be included in the screening ecological risk assessment (see Section 4.2). Where radionuclide and chemical toxicity data are available for individual species, they were compared with contaminant exposure estimates for Tier II species (see Section 4.2). Also, the exposure duration scoring is less meaningful because toxicity data are often based on 48-hour to 96-hour exposures. Even the lowest exposure duration for species given a score of 1 exceeds 48 hours. However, both acute and chronic exposures and risks are evaluated in Section 4.2. Finally, there was virtually no difference in the ranking of species within taxonomic groups based on composite scores and highest average summary scores (see point 8 above). Therefore, because the effect of the composite scores in the ranking of species is minimal, the highest average summary scores were considered to be more valuable than the composite scores for the purposes of this species screen.

4.1.2.2.12 Identification of Final Tier II Species. The CRCIA Team selected 65 of the ranked Tier I species (Table C.3, Appendix I-C, rows 28 and 35) as tentative Tier II species based on their rank and cultural and ecological importance. These were further reduced to 52 final Tier II species by excluding 1) those with a life style similar to that of another Tier II species, 2) those with low average summary scores, and 3) those that virtually never occur in the river or riparian zone.

Table 4.17 presents the results of ranking the Tier I species, based on highest average summary scores and composite scores, and identifies those selected as Tier II species with a (+) in the right hand column. The Tier II species are those evaluated in the screening assessment of ecological risk (Section 4.2). A high rank (a low numeric value) represents a high potential exposure to contaminated media. Footnote letters (c, d, and f) in the right-hand column indicate that a species was not selected for the final list of Tier II species for the reasons specified in the footnotes. The number and percent of Tier I species retained during the Tier II screening process are shown in Table 4.18.

4.2 Results: Ecological Risk Screening Assessment

To estimate the potential risk to the environment, we put the data described in Section 3.0, the species described in Section 4.1, and the parameters for those species described in this section into a computer model. The computer model consisted of a series of equations that estimated exposure to contaminants. In this section, we describe how the information from the three sources was used in the equations and what the results of the equations are. We used the exposure results to estimate the potential risk to the environment from contaminants in the Columbia River.

This section presents the analysis of the risk posed by contaminants for the Tier II species. Exposures are estimated using deterministic and stochastic models. Deterministic models use maximum source data and exposure data in a single run of the exposure model. Stochastic models use the same exposure model in a regime that uses the probability density functions for the input parameters. The deterministic models are run for all portions of the study area. The stochastic models are run for those portions of the study area where deterministic exposure exceeds a toxicological threshold. In this section, the model's composition, toxicological benchmarks, and results are described.

This screening ecological risk assessment generally follows EPA guidance for conducting such assessments (EPA 1996a, 1992a), with specific guidance used as deemed appropriate to the scope and requirements set by the CRCIA Team. The methodology used included defining conceptual exposure models, defining assessment endpoints, characterizing biotic exposure and effects, and characterizing risk to the assessment endpoints. However, this assessment has changed some of the terminology for easier understanding.

Table 4.17. Tier II Species

Taxonomic Groups/Species[(a)]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
Algae				
Periphyton	1	1	*	+
Phytoplankton	1	1	*	+
Amphibians				
Bullfrog	1	1	*	(b)
Spadefoot Toad	2	1	*	(c)
Woodhouse's Toad	2	1	*	+(b)
Aquatic Invertebrates				
Caddisfly	1	1	*	(c)
Crayfish	1	1	*	+
Fresh Water Shrimp	1	1	*	+
Mayfly	1	1	*	+
Midge	1	1	*	(c)
Clams/Mussels/Snails	1	1	*	+
Water Flea	10	10	*	+
Birds				
American Coot	1	1	*	+
Common Snipe	3	2	*	+
Canada Goose/Mallard	6	6	*	+
Diving Ducks (primarily carnivorous; e.g., bufflehead)	7	20	*	+
Great Blue Heron	8	5	*	+
Forster's Tern	9	22	*	+
American White Pelican	10	6	*	+
Pied-billed Grebe	10	6	*	(c)
Common Merganser	10	21	*	(c)
California Quail	13	11	*	+
Cliff Swallow	17	23	*	+
Red-winged Blackbird	18	24	*	(c)
Belted Kingfisher	18	24	*	(c)
Osprey	18	24	*	(c)
Bald Eagle	22	28	*	+
Northern Harrier	26	13	*	+
American Kestrel	27	14	*	+
Barn Owl	27	14	*	(d)

Table 4.17. (Cont'd)

Taxonomic Groups/Species[(a)]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
Emergent Vegetation				
Tule	1	1	*	+
Fish				
Channel Catfish	1	1	*	+
Largescale Sucker	2	2	*	+
Mountain Sucker	2	2	*	+
Piute Sculpin	4	4	*	(c)
White Sturgeon	6	6	*	+
Common Carp	6	7	*	+
Mountain Whitefish	6	7	*	+
Pacific Lamprey	8	16	*	+
Small Mouth bass	11	9	*	+
Trout (rainbow)	11	11	*	+
Trout (bull)	11	11	*	(c)
Northern Squawfish	11	11	*	(d)
Salmon (all)	11	17	*	+
Steelhead Trout	18	18	*	(c)
Fungi	1	1	*	+
Macrophytes				
Columbia Yellow Cress[(e)]	1	1	*	+
Water Milfoil	1	1	*	+
Duckweed	4	4	*	(c)
Mammals				
Muskrat	1	1	*	+
Beaver	3	3	*	+
Coyote	3	3	*	+
Raccoon	3	3	*	+
Short-tailed and Long-tailed Weasel	3	3	*	+
Mule Deer	3	10	*	+
Great Basin Pocket Mouse	4	11	*	(f)
Western Harvest Mouse	9	11	*	+
Reptiles				
Western Garter Snake	1	1	*	+
Side-blotched Lizard	3	6	*	+

Table 4.17. (Cont'd)

Taxonomic groups/Species[a]	Rank Based on Highest Average Summary Scores	Rank Based on Composite Scores	Selected by CRCIA Team as Tentative Tier II Species	Final Tier II Species
Terrestrial Vegetation				
Black Cottonwood	1	1	*	+
Dense Sedge	1	1	*	+
Fern (all)	1	1	*	+
White Mulberry	1	1	*	+
Reed Canary Grass	1	1	*	+
Rushes (all)	1	1	*	+
Willow (all)	1	1	*	[c]

(a) Terrestrial invertebrates are not included in this table because no species in these taxonomic groups were selected by the CRCIA Team as tentative Tier II species.

(b) The bullfrog, which received the highest rank, was not selected as the final Tier II species for the amphibian group. It is known to occur in ponds at the base of the White Bluffs along the Columbia River and in the W-B10 Wasteway Lake. According to an unpublished report by L.A. Hallock at the Nature Conservancy of Washington, the bullfrog may occur along the Hanford Reach, based on calls, but its presence there has not been confirmed by observation. Also according to Hallock, the adult Woodhouse's toad has been observed in the Columbia River sloughs, although it is not known whether it uses these sloughs for breeding. Because Woodhouse's toad has actually been observed using the Columbia River and because it is a state monitor species, Woodhouse's toad was selected as the final Tier II species for the amphibian group, although it received a lower rank than the bullfrog. The bullfrog is not native to this area.

(c) Species with a life style and exposure scenario similar to that of another Tier II species:
- Belted King Fisher and osprey similar to bald eagle
- Bull trout similar to rainbow trout
- Caddisfly similar to mayfly
- Common merganser similar to American coot
- Duckweed similar to Columbia yellowcress
- Midge similar to mayfly
- Pied-billed grebe similar to diving duck
- Piute sculpin similar to channel catfish
- Red-winged blackbird similar to cliff swallow
- Spadefoot toad similar to Woodhouses's toad
- Steelhead trout similar to salmon
- Willow similar to all the other selected terrestrial vegetation

(d) Species with low average summary scores.

(e) Although not strictly a macrophyte, Columbia yellowcress is grouped with them because it is submerged part of the year and has much the same exposure characteristics as macrophytes.

(f) Species that virtually never occur in the river or riparian zone.

\+ One of the 52 Tier II species

Table 4.18. Number of Tier I Species by Taxonomic Group Retained in the Tier II Species Screen

	Algae	Amphibians	Aquatic Invertebrates	Birds	Emergent Vegetation	Fish	Fungi	Macrophytes	Mammals	Reptiles	Terrestrial Invertebrates	Terrestrial Vegetation	Total
No. of Tier I Species	12	4	15	48	8	24	1	5	21	7	7	29	181
No. of Tier I Species Selected by the CRCIA Team as Tentative Tier II Species	2[(a)]	3	7	18	1	14	1	3	8	2	0	7	66
Percent of Tier I Species Selected by the CRCIA Team as Tentative Tier II Species	17%	75%	47%	38%	13%	60%	100%	60%	38%	29%	0%	24%	36%
No. of Tier I Species Selected as Final Tier II Species	2[(a)]	1	5	12	1	10	1	2	7	2	0	6	52
Percent of Tier I Species Selected as Final Tier II Species	17%	25%	33%	25%	13%	42%	100%	40%	33%	29%	0%	21%	29%

(a) Periphyton and phytoplankton, two broad taxonomic groups that include many algae species, were selected as tentative and final Tier II species (see Table 4.17).