

## **6.0 Data Quality and Uncertainty**

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These results were calculated by using the best available knowledge about the Amchitka marine environment assembled and synthesized from many sources. For example, the best estimate of potential groundwater flux at the ocean floor is the mean or average of the results of groundwater modeling with peer-reviewed models. Modeling the dispersion of radionuclides in seawater used an EPA-approved model (CORMIX). In turn, this model used the best available data from Amchitka on current velocity, salinity gradients, and other inputs.

Whenever precise data were lacking or if there was uncertainty about parameters, values were conservatively chosen from the available data to calculate higher potential exposures rather than lower exposures. For example, subsistence fishers (Sections A.7 and A.8) were modeled as eating more fish than reported by Aleut communities, all people in all non-Aleut populations were assumed to eat fish from the Bering Sea and northern Pacific Ocean at conservative consumption rates (Section A.8.0), and marine fish and mammals were modeled in food chains (Section A.9.0 and Section A.10.0) as having higher uptake factors from seawater and food than is likely in a real setting. Subsistence consumers (Section A.8.0) were modeled as eating a quantity of food per day that is an upper bound of reported ingestion rates. Subsistence fishers (Section A.10.0) were assumed to fish in an area where they could harvest contaminated fish for a longer period of the time than is likely. Further, the screening level of  $1 \times 10^{-6}$  or one excess cancer case in a million people (Section A.12.0) is considered by the EPA to be below the level of concern. Thus, conservative values were used in the absence of precise data.

Although the best estimates of parameter values were used, some could be above or below the actual numerical values. For nearshore exposure (Section A.6.2.2), the groundwater fluxes are mean values and could be higher or lower (CORMIX model input parameter values are based on measured conditions near Amchitka, and the dilution factor for each plume is based on best scientific judgment and could be higher or lower). The dilution factor for offshore exposure (Section A.6.2.3) is based on a published dilution model, but it also has some uncertainty. Cancer morbidity risk coefficients (Section A.11.0) are central tendency values that EPA states have some uncertainty, and the actual coefficient could be higher or lower. In such situations, a conservative value was used as appropriate in a screening risk assessment.

Uncertainties also exist in the groundwater flow and transport modeling that feeds into the risk assessment. The same technical approach was used in that effort whereby parameter values were chosen to allow more rapid transport than slower, if precise data were lacking. For example, although limited data with significant uncertainties indicate the fracture porosity at Amchitka is on the order of  $1 \times 10^{-3}$ , a value of  $5 \times 10^{-4}$  (resulting in faster groundwater velocities) was used for the mean porosity in the modeling in order to be conservative. A parametric uncertainty analysis was performed for the groundwater modeling and those parameters whose uncertainty significantly impacted the radionuclide breakthrough were included as uncertainties in the final modeling. This allows the consequences of uncertainty to be quantified for the groundwater model, expressed as a standard deviation of the breakthrough curves. Including the standard deviation in the risk calculations allows the groundwater model uncertainty to be carried into the risk assessment. The mean plus two standard deviations presented in this report is a highly conservative expression of the uncertainty coming from the groundwater model. The mean minus two standard deviations (and the mean minus one standard deviation as well) is equally valid and shows no release of radionuclides from any of the tests to the seafloor in 1,000 years.

Uncertainty about the selection of radionuclides of potential concern (Section A.2.0) and calculation of risk using output of other sections (Section A.14.0) is expected to have little effect on the results because there is little uncertainty about these elements. Uncertainty about the locations of releases (Section A.3.0), seabed substrates (Section A.4.0), transport by currents (Section A.5.0), and biomass density of fish (Section A.10.0), have a minor mathematical influence on the results.

In summary, the screening risk assessment used conservative data and conservative assumptions, and the results show potential risk levels to be well below the most conservative EPA risk thresholds for both subsistence users and commercial catch consumers. Because many of the parameter values were chosen to be very conservative, the results may overstate the risks by more than two orders of magnitude.

## 7.0 Summary

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1. The most significant finding is that risks to human health from all the dietary exposure scenarios and locations from the sum of 19 selected radionuclides potentially released from the detonations are calculated to be well below EPA's lower limit of concern and so low that EPA considers them to be undetectable. The calculated lifetime excess cancer risks for the best estimate of groundwater flow and transport range from  $8.9 \times 10^{-13}$  to  $9.7 \times 10^{-11}$ . This is 10,000 to 1,000,000 fold lower than EPA's point of departure for a risk value of  $1 \times 10^{-6}$ .
2. Uncertainty in the estimate of groundwater flow and transport is expressed as a standard deviation for the mean flux. Considering two standard deviations added to the mean allows a highly conservative expression of uncertainty. The calculated lifetime excess cancer risks for the mean plus two standard deviations of radionuclide flux ranges from  $1.5 \times 10^{-11}$  to  $1.6 \times 10^{-9}$ . If the upper bound of uncertainty is considered, the lower bound must be as well. Two standard deviations subtracted from the mean mathematically yields no radionuclide flux to the environment and no excess cancer risk. Therefore, a highly conservative range of groundwater flux values yields risks ranging from no excess risk to 600-fold below EPA's point of departure.
3. A sensitivity analysis was also performed with the groundwater model, allowing more rapid transport by reducing matrix diffusion below the best estimate. The calculated lifetime excess cancer risk for the sensitivity case ranged from  $1.5 \times 10^{-10}$  to  $1.9 \times 10^{-8}$  for the mean,  $1.4 \times 10^{-9}$  to  $2.3 \times 10^{-7}$  for the mean plus two standard deviations, and no excess risk for the mean minus two standard deviations. Thus, even incorporating significant conservatism into the calculation of radionuclide flux through groundwater, the risk is still well below EPA's lower limit of concern.
4. Conservative values for risk assessment model parameters were chosen from the best available knowledge. The degree of conservatism in the choice of parameters for dispersion modeling, definitions of the exposed populations, percent of diet coming from the vicinity of Amchitka, amount of fish and marine mammals consumed in the diet, and bioconcentration factors for radionuclides contributed to an overestimate of risk by an estimated two orders of magnitude or more.
5. The predicted lifetime risk values for the nine scenarios for the mean radionuclide flux are ranked from highest to lowest in Table 8, with the highest mean flux value  $9.7 \times 10^{-11}$ . This value is for the scenario of fish subsistence dietary exposure at the combined Cannikin, Long Shot, and Milrow location (with or without kelp), groundwater model base case.
6. The maximum lifetime risk value of  $9.7 \times 10^{-11}$  occurred for exposure beginning in 1968, three years after the first detonation in October 1965. Risks have decreased since that time and are predicted to continue to decrease through the year 2965 and beyond the modeled period.

7. The lowest of the maximum lifetime risk values for the mean radionuclide flux,  $8.9 \times 10^{-13}$ , was for the commercial catch dietary exposure, Aleut culture and communication area location, base-case groundwater model scenario.
8. For all nine risk scenarios that were evaluated, the lifetime risk values for the mean radionuclide flux for the sensitivity-case groundwater model were approximately 100-fold greater than lifetime risk values for the mean radionuclide flux for the base-case groundwater model.

In summary, the most important result of the Amchitka Island human screening risk assessment is that the predicted lifetime risk values for the mean radionuclide flux from the 19 radionuclides released from the test detonations in 1965, 1969, and 1971 ranged from approximately 10,000-fold to 1,000,000-fold below EPA's point of departure for risk ( $1.00 \times 10^{-6}$ ). Even incorporating significant uncertainty into the calculation of radionuclide flux through groundwater and adding additional conservatism in the risk assessment parameters, the risk is still well below the EPA's lower level of concern. These values were predicted for the entire 1,000-year period from 1965 through 2965 for all nine risk scenario combinations of dietary exposure, locations, and groundwater model type.

## 8.0 References

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