

8.0 Uncertainty analysis

There are many assumptions involved in risk assessment. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that the health of local residents is protected. Therefore, when all of the assumptions are combined, it is much more likely that actual risks, if any, are overestimated rather than underestimated.

The assumptions that introduce the greatest amount of uncertainty in this risk assessment are discussed in this section. They are discussed in general terms, because for most of the assumptions there is not enough information to assign a numerical value that can be factored into the calculation of risk.

8.1 Hazard identification

During the Hazard Identification step, compounds are selected for inclusion in the quantitative risk assessment from a list of all compounds known or expected to be emitted from the source(s) studied. Uncertainty is introduced in three principal areas during this step: (1) selection of compounds for inclusion in the quantitative risk assessment based on emissions and modeling results, (2) estimation of emissions and (3) air quality modeling.

8.1.1 Selection of compounds

The compounds quantitatively evaluated in the risk assessment were selected by Weston in its 1989 health assessment, based on data for other resource recovery facilities throughout the world. The ENSR (2004) risk assessment for the RRF was also based on these compounds. The selection of these 21 COPC focuses the risk assessment on those pollutants for which there were no established air quality standards, but for which there was a body of evidence that indicates potential effects on humans. Based on an assessment of the literature available on this subject, the compounds evaluated in this risk assessment represent key compounds in typical emissions from resource recovery facilities.

8.1.2 Emission rates

Emission rates for the COPCs were developed for the RRF from 18 stack emission measurements conducted from 1995 through 2000. Emissions data for the Mirant coal units were obtained from the 1989 MDNR study which were also based on stack measurements. Emissions for the Mirant combustion turbines and NIH boilers were estimated based on available emission factors from U.S. EPA (AP-42 Emission Factor Document) and from Electric Power Research Institute (EPRI).

Emission rates representative of normal operating conditions were developed for each chemical analyzed in the RRF stack tests, and in some cases conservative estimates of emission rates were utilized for COPC detected infrequently in the stack tests. In general, average emission rates were used for each chemical measured in RRF emissions. In calculating the average emission rate however, non-detect chemicals were retained in the calculations at a level equivalent to a method detection limit-derived reliable detection limit (MDL-derived RDL). Typically the MDL-derived RDL is 2.623 times the method detection limit (MDL) reported by the laboratory. Therefore, compounds detected infrequently in RRF emissions, such as beryllium, were evaluated in the cumulative health risk assessment using emission rates that are likely to be over-estimated.

8.1.3 Air quality modeling

A U.S. EPA-approved computerized air dispersion model has been used to estimate air concentrations and deposition rates resulting from air emissions of each facility. The dispersion model provides information

regarding how particulates and gases emitted from each facility disperse, or spread, after they are released from the stack. U.S. EPA-specified deposition algorithms are applied to the results of the dispersion modeling to estimate deposition rates.

Dispersion model evaluation studies have shown that models such as ISCST3 estimate air concentrations to within about a factor of 2 compared to observations.

8.2 Toxicity assessment

Dose-response values are usually based on limited toxicological data. For this reason, a margin of safety is built into estimates of both carcinogenic and noncarcinogenic risk, and actual risks are most likely lower than those estimated. The two major areas of uncertainty introduced in the dose-response assessment are: (1) animal to human extrapolation; and (2) high to low dose extrapolation. These are discussed in the following subsections.

8.2.1 Animal to human extrapolation

Human dose-response values are often extrapolated, or estimated, using the results of animal studies. Extrapolation from animals to humans introduces a great deal of uncertainty in the risk assessment because in most instances, it is not known how differently a human may react to the compound compared to the animal species used to test the compound. The procedures used to extrapolate from animals to humans involve conservative assumptions and incorporate several uncertainty factors that overestimate the adverse effects associated with a specific dose. As a result, overestimation of the potential for adverse effects to humans is more likely than underestimation.

8.2.2 High to low dose extrapolation

Predicting potential health effects from facility air emissions requires the use of models to extrapolate the observed health effects from the high doses used in laboratory studies to the anticipated human health effects from low doses experienced in the environment. The models contain conservative assumptions to account for the large degree of uncertainty associated with this extrapolation (especially for potential carcinogens) and therefore, tend to be more likely to overestimate than underestimate the risks.

8.3 Exposure assessment

During the exposure assessment, exposure point concentrations are estimated and exposure doses calculated. Exposure point concentrations are the estimated concentrations of compounds to which humans may be exposed. Once the concentrations in an environmental medium such as soil, water, or air have been predicted, the calculation of human exposure and dose involves making additional assumptions. The major sources of uncertainty associated with these assumptions are discussed below.

8.3.1 Estimation of surface water and sediment concentrations

The compound concentrations in surface water and sediment in the Potomac River were estimated using equations provided in U.S. EPA (1998). Assumptions about adsorption of compound particles in the air, the amount and rate of soil runoff, the deposition of particles, the rate of compound degradation, and the size of the watershed area, are included in the U.S. EPA model. Each assumption has uncertainty associated with it, particularly because input data were based on U.S. Geological Survey (USGS) or Soil Conservation Service (SCS) information for the general area. Estimating surface water and sediment compound concentrations also involves numerous assumptions regarding the fate and transport of compounds, and the hydrology of local waterbodies, such as turn-over patterns and flow rates. These assumptions are conservative to provide reasonable assurance that the evaluation of surface water and sediment exposures does not understate actual exposures.

8.3.1.1 Degradation of selected compounds

The risk assessment assumes that all selected organic compounds degrade slowly in surface waters and not at all in soils. Inorganic compounds were assumed not to degrade in soil and surface water. These assumptions ignore processes that, in reality, result in the loss of compounds from soil and water. Therefore, risks to human health are likely to be overestimated.

8.3.1.2 Estimation of Compound Intake from Food

Estimation of potential compound intake in the food consumed by the receptors evaluated incorporates many assumptions. Conservative estimates are made about the uptake of compounds into root crops, leaf crops, beef, dairy, pork and chicken products. Parameters, such as root uptake factors and air-to-leaf transfer factors for the produce pathway, and biotransfer factors for the beef and dairy pathways, are high-end estimates provided in U.S. EPA (1998) and may not represent actual conditions at the study area.

People may be exposed to compounds in the soil through ingestion of crops and inadvertent ingestion of soil. Because the compounds deposited on the soil surface are bound to or mixed with soil particles, conservative assumptions were made concerning the intake of the compounds by receptors. The conservative assumptions were made to provide reasonable assurance that the evaluation of risks from exposure to soil is not understated. Each conservative assumption tends to overestimate, rather than underestimate, potential risks.

Fish in area waterbodies may accumulate compounds in their tissues. Accumulation of compounds in fish tissue is estimated using bioconcentration factors (BCFs) and bioaccumulation factors (BAFs) that are estimated from fish studies which may not reflect actual area conditions. The use of BCFs and BAFs introduces uncertainty into the predicted fish tissue concentrations.

8.3.1.3 Estimation of Exposure Dose

Once the concentrations of the facility-related compounds in water, soil, air, and food have been predicted through modeling, the extent of human exposure must be estimated. This requires making assumptions about the frequency and duration of human exposure to water, soil, air and food.

There are many assumptions that must be made regarding exposure to soil, ingestion of garden produce, beef, milk and fish. These assumptions are mainly based on data compiled by the U.S. EPA (U.S. EPA, 1997; and 1998) and are representative of "reasonable maximum" estimates. These reasonable maximum estimates for various exposure assumptions generally represent the upper end of a potentially wide range of values and may not accurately represent exposures for people living in the study area. Actual human exposures are usually lower than those assumed in the risk assessment.

8.4 Risk characterization

The risk of adverse human health effects depends on estimated levels of exposure and dose-response relationships. Two important additional sources of uncertainty are introduced in this phase of the risk assessment: (1) the evaluation of potential exposure to more than one compound; and (2) the presence of subpopulations which may be particularly sensitive.

8.4.1 Risk from multiple compounds

Once exposure to and risk from each of the selected compounds is calculated, the total risk posed by cumulative impacts of facilities in the study area is estimated by combining the health risk contributed by each compound. For virtually all combinations of compounds potentially released from resource recovery facilities, there is little or no evidence of interaction. However, in order not to understate potential risk to human health, it is assumed that carcinogenic effects of different compounds may be added together. Noncarcinogenic

effects are often summed, as in this report, although this is less appropriate because different compounds may have different health endpoints (e.g., neurotoxicity, liver effects, respiratory irritation). The amount of uncertainty associated with summing the effects varies on a case-by-case basis.

8.4.2 Combination of several upper-bound assumptions

Generally, the goal of risk assessment is to estimate an upper-bound, but reasonable, prediction of potential risk to human health. Most of the assumptions about exposure and toxicity used in this assessment are representative of statistical upper-bounds or even maxima for each of the parameters. The result of combining several such upper-bound assumptions is that the final estimate of potential exposure or potential risk is very conservative, lead to likely overestimation of potential risk to human health.