Development of Risk-based Instream Water Quality Values for Bear Creek

To derive site-specific fish tissue preliminary remediation goals (PRGs) for radionuclides that can reliably be used to calculate water column PRGs, the number of fish meals combined with the appropriate receptor-specific exposure assumptions are needed. The number of fish meals is dependent upon the total number of fish available to be caught within a particular fishery, the number of edible fish (defined for this evaluation as fish weighing greater than 30 grams), fraction of fish ingested or fish yield (as percent of whole fish), and the fish catch success rate. Typical angler exposure assumptions needed to model the risk include information on exposure frequency, exposure time and duration, number of fishing trips, and fraction of edible fish ingested (in grams per meal).

Three points of exposure (POE) along Bear Creek/Poplar Creek were identified for this evaluation. Each POE stretches approximately one kilometer and have similar habitat with the potential for fishers to gain access to these stream reach locations. **Table 1** presents the rationale for POE selection and description of the three stream reach locations. These stream reach locations listed in the order of closest to furthest away from the waste discharge point (Environmental Management Waste Management Facility or EMWMF) are BCK 3.3 – 4.5 (BCK 3.3), BCK 0.5 – 1.5 (BCK 0.5), and EFK 0.0 – 1.0 (EFK 0.0) (**Figure 1**) (DOE, 2021). EFK 0.0 is located at the confluence of East Fork Poplar Creek and Poplar Creek. Despite not being a part of Bear Creek, EFK 0.0 was included in the fish sampling to help bound the risk from radionuclides in fish tissue in the event radionuclides are detected in Bear Creek. The following sections describe how each parameter variable in the water-column PRG calculations were developed including the number of fish meals.

Fish Meals Approach

Fish Catch Rate

The fish catch rate is a valuable measure of potential fishing success (i.e., catch per unit of fishing effort) and it is a key determinant in the number of potential fish meals at a given POE. Since a roving creel survey has not been conducted for Bear Creek to allow for calculation of a site-specific catch rate and fish ingestion rate, EPA has proposed the use of available information from several sources which include: 1) the Tennessee Wildlife Resources Agency's (TWRA) Creel Survey Report (TWRA, 2019) conducted for a nearby sports fishery (Melton Hill), 2) TDEC's ongoing Roving Creel Report for Poplar Creek (TDEC, 2021; Draft), 3) results from the Spring 2021 fish sampling event, 4) Spring 2021 fish community survey, and 5) the last five years (2016-2020) of edible-sized fish data collected for BCK 3.3 as part of the BMAP monitoring program. This evidence-based fish meal approach incorporates a fish catch rate based on the average catch success percentages for the two POEs identified along Bear Creek (i.e., BCK 3.3 and BCK 0.5). The furthest downstream POE (EFK 0.0) was excluded from the calculation of the average catch rate because it is not a part of Bear Creek, so it does not represent fishing activities for the stream reaches of interest. However, this location was included in the fish sampling to gain an understanding of the baseline radionuclide risk in fish downstream of Bear Creek.

An extrapolation method was employed for this evaluation since a roving creel survey is not available. The method used to determine the fish catch success percentages for the POEs was adopted from the TWRA 2019 creel report. This method is typically used by the TWRA to calculate catch success when setting catch limits for sports fishermen such that the available fish population can be used in a sustainable manner. The creel survey method consists of estimating the total fishing effort in a day (or portion of a day) and the average catch rate. The effort is estimated in angler-hours and the catch

success rate (or percentage) in fish per angler-hour. The catch success for Melton Hill was extrapolated for Bear Creek (BCK 0.5 and BCK 3.3) based on Melton Hill's conservative 6-hour fishing trip (i.e., total fishing effort) and the catch per hour estimates were calculated based on the total number of fish per POE as determined via the electrofishing fish collection method. According to the TWRA creel report, most recreational fishers at Melton Hill reported fishing for a 6-hour period (typically 3 hours in the morning and 3 hours in the afternoon). According to the TWRA 2019 creel report, the catch per hour range over a 6-hour fishing trip for Melton Hill was measured at 0.14 to 2.05 catch per hour. The catch per hour for Melton Hill is 1.213 based on the 95% upper confidence limit (UCL) on the mean. This equates to 7 fish per fishing trip (i.e., 1.213 fish caught/hour x 6 hours = 7.28 fish per trip). This estimate can also be considered a regional estimate of catch success for similar creeks in the area. Of importance, Melton Hill provides a more diverse and abundant fish community making it a more attractive fishery when compared to Bear Creek. Therefore, it is reasonable to assume that extrapolating the catch per hour from Melton Hill and applying it to edible-size fish caught in Bear Creek is a conservative approach that represents reasonable maximum exposure (RME).

To extrapolate the catch success from Melton Hill to Bear Creek, the 7 fish per trip is divided by the total number of edible-sized fish (regardless of species type) collected during the fish sampling at each POE. As a rule of thumb, fish catch success depends on the length of time spent fishing and the total effort (defined by the number of fish caught per hour). This assumption is then correlated with the number of fish available to be caught at a given POE. However, this extrapolation method relies on the presence of an adequate fish population, which was not the case for BCK 3.3. To reliably assess this reach of the creek, the one edible fish recorded at BCK 3.3 (i.e., the POE nearest the point of discharge) during the fish sampling was conservatively combined with the fish population identified over the last five years of BMAP monitoring at this POE. Therefore, the fish catch rate at BCK 3.3 represents the fish population over the last 5 years. Applying this conservative approach to BCK 3.3 also counters the potential for seasonal variation and potential habitat changes in the future. This approach was not applied to BCK 0.5 because the fish population size was sufficiently robust to compute a reliable fish catch percentage.

To derive the catch rates (expressed as percentages) at each of the two POEs along Bear Creek, the Melton Hill catch rate was divided by the total number of edible-size fish collected at each POE. This results in a catch rate of 58% at BCK 0.5 and 27% at BCK 3.3. Thus, the extrapolated average catch rate for Bear Creek is 43%. Note that the average fish catch rate was used in lieu of the maximum fish catch rate to better represent the entire stretch of the creek and to also account for instances where fishers may only target specific species of fish for consumption or elect to fish in other nearby fisheries throughout the year.

Total Fish Biomass

Due to the limited number of edible fish species collected at BCK 3.3 during the Spring 2021 fish sampling, fish counts collected between 2016 to 2020 for the BMAP program were used to supplement the dataset at BCK 3.3. Combining the BMAP fish weight data with the Spring 2021 fish weight at BCK 3.3 resulted in an increase in the fish count from one to 27 total fish and an increase in total fish biomass from 38.1 grams to 99.2 grams (based on the 95th percentile of fish weights). This allowed for a more robust estimation of the fish catch rate at BCK 3.3. For BCK 0.5, the total summed fish weights were based on measurements from the Spring 2021 fish sampling event. To err on the side of conservatism, all fish greater than 30 grams caught via the electrofishing sampling technique were factored in the calculation of the total fish biomass.

The Burger et al. (2008) study that was conducted along the Clinch River arm of Watts Bar Reservoir adjacent to the Oak Ridge Reservation was also considered to further validate the type of fish species being consumed by local recreational fishers and the predominant fish preparation method. Burger et al. (2008) interviews conducted along East Fork Poplar Creek and Clinch River reported that the percentage of fish eaten whole for all anglers interviewed was less than 4% and about 1.5% for anglers in the study area. Therefore, fish is mostly consumed in the filleted condition. Based on this information, total fish biomass for the two Bear Creek POEs were based on edible fish fillets (muscle tissue) only. The extent to which skin is eaten is not addressed here since reliable information is lacking.

Number of Fishing Trips

The number of fishing trips are time-weighted over a 9-month fishing period as reported in TDEC's Roving Creel report. TDEC conducted interviews of local recreational fishers fishing in Poplar Creek. It was recognized that fishing frequency and activity would vary over the nine months. Therefore, it was assumed that recreational fishers would conduct four fishing trips per month for six months (late Spring, Summer and Fall) and two trips per month over three months (during colder or inclement weather not allowing for favorable fishing conditions). This resulted in a total of 30 fishing trips per year.

Fraction of Edible Fish/Fish Yield

According to available studies in the literature, 38-58% of whole fish on average is edible and varies depending on type of fish species. However, data on fish yield is limited in the scientific literature. Notably, the fish population in Bear Creek varies in size with a higher population of sunfish. The maximum weight of sunfish in Bear Creek was 73 grams (0.16 pounds). A few larger fish were also captured at BCK 3.3 and BCK 0.5. Therefore, 50% edible fraction was assumed in the fish meals calculation. This is presumed to be a conservative estimate based on the type of fish species present, laboratory whole fish versus fillet/muscle tissue weights, the length-to-weight ratios, and the prevalence of smaller fish comprising the fish population in Bear Creek.

Total Ingested Fish per POE

To derive the total mass of fish consumed over the 9-month period, the average fish catch success rate for BCK 3.3 and BCK 0.5 were multiplied by the total number of fishing trips and the fraction of edible fish. For example, the total ingested fish at BCK 0.5 was calculated as follows: 0.43 (average fish catch rate) x 30 fishing trips x 0.5 (50% edible fish portion) x total weight of fish greater than 30 grams (682 grams). This equates to 4,400 grams (10 pounds) per year at this stream reach location. For BCK 3.3, the total ingested fish was 640 grams (1.4 pounds) per year (1.4 pounds per year) (i.e., 0.43 average fish catch rate x 30 fishing trips x 0.5 edible fraction x 99.2 grams).

Representative Fish Meals

To obtain the number of representative fish meals at BCK 3.3 and BCK 0.5, the total ingested fish per POE expressed as grams of fish eaten per year at each POE was then divided by the number of grams per fish meal. The number of grams per meal was assumed to be equivalent to the Clean Water Act's default value of 227 grams/meal (i.e., 8-ounce fish meal). This resulted in approximately three fish meals per year at BCK 3.3 (i.e., 640 grams per year / 227 grams per meal) and 19.4 meals per year at BCK 0.5 (i.e., 4,401 grams per year / 227 grams per meal). To derive a representative estimate of fish meals for the entire stream reach based on the estimates calculated for the two reasonable maximum POEs,

the average fish meal estimate (i.e., 11 fish meals per year) for the two POEs was used in the risk-based fish tissue PRG calculations.

Development of Preliminary Remediation Goals

Fish Tissue PRGs

To calculate the fish tissue PRG, the baseline risk in the fish is first determined and back-calculated to a PRG using the target risk of 1e-05. The baseline risk is the product of the cancer toxicity value (isotope specific) as provided in EPA's Radionuclide PRG online calculator (EPA, 2021), the exposure duration (26 years), the average fish tissue concentration (95% UCL), and the fish ingestion rate in grams per year (11 fish meals/year X 227 g/meal = 2,500 grams/year). Consistent with CERCLA recommendations for risk assessments, the target risk is divided by the product of the cancer toxicity value, the ingestion rate (in grams per year) and the exposure duration of 26 years over 350 days/year to calculate the fish tissue PRG. These exposure assumptions are the default values recommended by EPA (2014). The standard fish tissue PRG equation is presented below.

Fish Tissue PRG Equation:

$$\frac{1\mathrm{E}-05}{\text{Oral Ingestion Cancer Slope Factor } \left(\frac{\text{risk}}{\text{pCi}}\right) \text{ x Ingestion Rate } \left(2500\ \frac{\text{g}}{\text{yr}}\right) \text{ x Exposure Duration (26 years)}}$$

Water Column PRGs

The water column PRG is expressed as the ratio of the radioisotope-specific fish tissue PRG and the default bioconcentration factor available for each radioisotope. EPA obtained all default bioconcentration factors from EPA's Radionuclide PRG online calculator (EPA, 2021). The standard water column PRG equation is presented below.

Water Column PRG Equation:

$$\frac{Fish\ Tissue\ Concentration\ (\frac{pCi}{g})}{Bioconcentration\ Factor\ \left(\frac{pCi}{kg}\ per\ \frac{pCi}{L}\right) x\ Conversion\ Factor\ (1{,}000\ \frac{g}{kg})}$$

Study Limitations and Recommendations

It is recognized that fish habitats and populations can favorably change over time, and as a result, recreational use of the creek may increase for these stream reaches. Conversely, fish populations can further decline due to seasonality and water chemistry changes. Therefore, EPA has conservatively designed this approach using scientifically defensible methods and default parameters consistent with CERCLA risk assessment protocols while also strongly recommending implementation of a robust fish and surface water monitoring program for radionuclides. EPA also recommends a creel survey for Bear Creek. However, given what is currently known about fishing activity in Bear Creek and the inherent

conservatism in the parameters selected, there is low likelihood that the fish catch success percentages at BCK 0.5 and BCK 3.3 are greater than the percentages determined for this evaluation.

It is acknowledged that this analysis is specific to radionuclides anticipated to be associated with the proposed EMDF and Bear Creek. If constructed, the proposed EMDF will operate for approximately 20 years before it is capped and closed.

References

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Table 1. Fish Sampling Stream Reach Location in Bear Creek

Stream Reach	Site Name	Rationale for Selection/Location Description
BCK 3.3 – 4.5	BCK 3.3	Stream access from unnamed gravel road off Hwy 95 upstream to triangle intersection of Hwy 95 and Bear Creek Road
BCK 0.5 – 1.5	BCK 0.5	Stream crossing on greenway trail
EFK 0.0 – 1.0	BCK 0.0	Lower East Fork Poplar Creek accessible by bridge from greenway trail

BCK – Bear Creek kilometer
EFK – East Fork kilometer
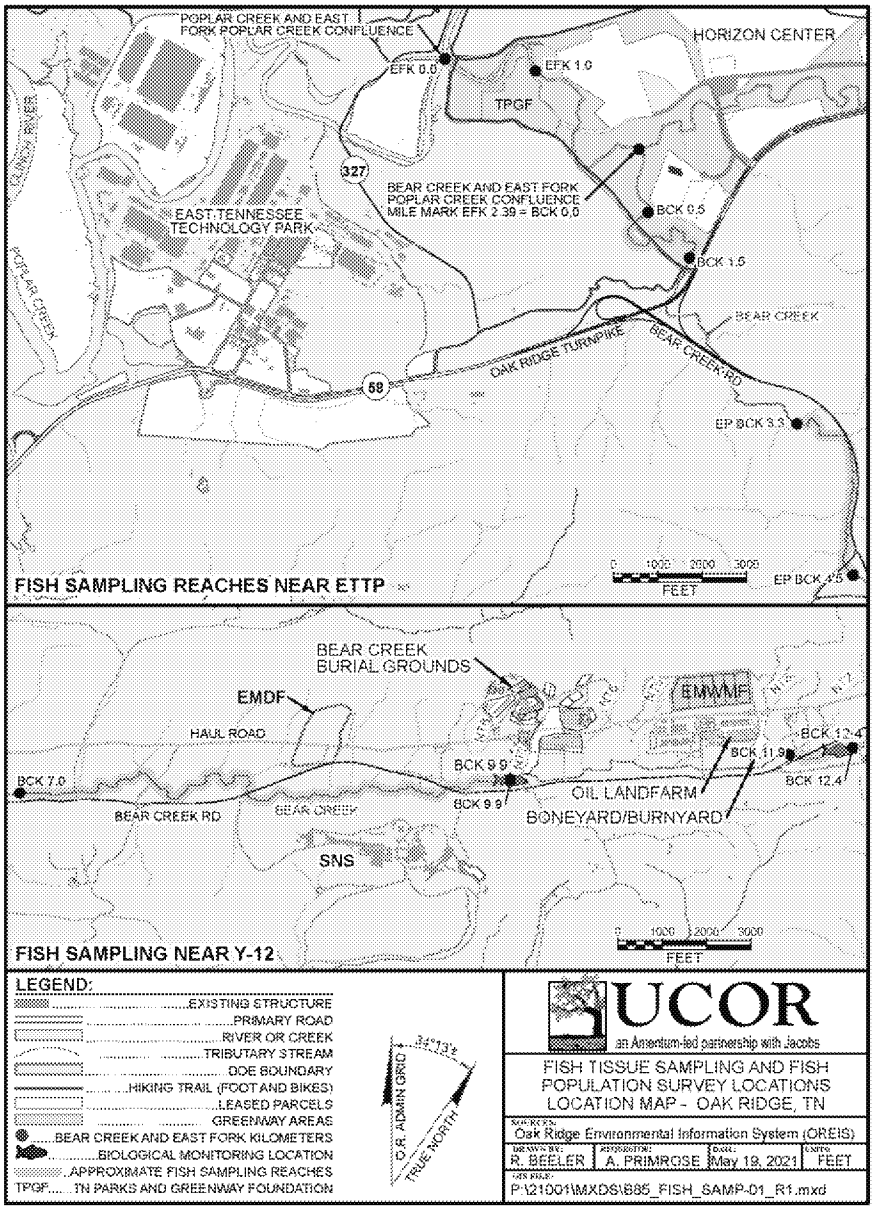
Figure 1. Fish Sampling Reaches in Bear Creek