ATTACHMENT C

Analysis of the Application of the Relative Source Contribution to Derivation of Human Health Water Quality Criteria

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(NCASI, July 2016)

Background

Some equations used to derive human health-based water quality criteria (HHWQC) include a parameter termed the Relative Source Contribution (RSC). The RSC describes the contribution of a contaminant from one or more sources relative to a total exposure from all sources. The Agency's justification for including RSCs in criteria for drinking water and HHWQC is provided in several documents. Related statements from some of these are as follows:

> "To determine the RMCL [Recommended Maximum Contaminant Level], the contribution from other sources of exposure, including air and food, should be taken into account." (EPA 1985)
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> "The 1980 AWQC National Guidelines recommended that contributions from non-water sources, namely air and non-fish dietary intake, be subtracted from the Acceptable Daily Intake (ADI), thus reducing the amount of the ADI 'available' for water-related sources of intake." (EPA 2000).
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> "EPA emphasizes that the purpose of the RSC is to ensure that the level of a chemical allowed by a criterion or multiple criteria, when combined with other identified sources of exposure common to the population of concern, will not result in exposures that exceed the RfD or the POD/UF". (EPA 2000).
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> ". . . to ensure that the level of a contaminant in drinking water, when combined with other sources of exposure (e.g. food and air) will not result in a total exposure for an individual that exceeds the reference dose." (GAO 2011).

Consistent with the above statements, the RSC is a factor multiplied by the reference dose (RfD) for the purpose of apportioning only part the RfD to, in the case of HHWQC, exposure through consumption of drinking water and fish. This parameter has been discussed as part of HHWQC derivation since 2000 (EPA 2000), though between 2000 and 2015 a value of 1.0 (i.e., 100% and effectively negating the RSC) was most commonly used when calculating EPA's recommended HHWQC criteria (EPA 2002). Only recently did EPA incorporate the RSC for most of the relevant criteria (EPA 2015a) and also apply upper and lower-bound limits on the RSC, 80% and 20%, respectively.

For purposes of deriving HHWQC, EPA has established two procedures for calculating the RSC, the "subtraction" method and the "percentage" method. In the subtraction method, the exposure supported by the RfD is allocated among various sources by first subtracting all exposure routes other than drinking water and fish consumption and then allocating the remainder of the RfD to drinking water and fish consumption. The percentage method is a simple ratio of exposure via

drinking water and fish consumption to the total exposure. EPA has developed a decision tree for choosing both the method and ultimate value of the RSC (Table 4.1 in EPA 2000). In most cases, EPA recommends the use of the percentage method. EPA's policy preference for the percentage method is evident (EPA 2000, GAO 2011, EPA 2015b), though the justification, particularly as it relates to the existence of other media criteria, is unclear.

The purpose of this paper is to contrast these methods mathematically and in context with the purpose for establishing an RSC.

The Subtraction Method

EPA's 2000 HHWQC guidance (EPA 2000) does not contain an equation for calculating the RSC using the subtraction method. Rather it is described as: "In the subtraction method, other sources of exposure (i.e., those other than the drinking water and fish exposures) are subtracted from the RfD (or POD/UF)." Thus, it would appear that the intent of this method is to apportion the remainder of the RfD (i.e., the RfD-supported exposure less other, non-drinking water and fish exposures) to drinking water and fish exposures. Examples of the calculation methodology are provided in two, more recent documents (GAO 2011, USEPA 2015b).

The example described in GAO 2011 (for drinking water) is:

1. subtract all non-drinking-water exposures from the reference dose to determine the amount of the reference dose "available" for exposure through drinking water,
2. determine what percentage of the reference dose that remainder represents, and
3. apply the resulting percentage as the relative source contribution.

The example described in EPA 2015b is:

1. Calculate the RfD-supported exposure for the population of interest,
2. Subtract the exposures for drinking water + fish/shellfish
3. Determine the percentage of the RfD-supported exposure represented by the remainder
4. Apply the upper/lower bound limitation, if necessary.

Based on the descriptions of the subtraction method in both EPA (2000) and GAO 2011, the example provided in EPA 2015b appears to have been calculated incorrectly. Specifically, step 2 should show the subtraction of exposures from non-drinking water, non-fish/shellfish sources instead of the subtraction of exposures from drinking water+fish/shellfish.

Example calculations using the method described in GAO 2011 (applied to a HHWQC derivation) and the incorrect equations shown on slide No. 9 of EPA 2015b are provided in Table 1. The calculation procedure described in GAO 2011 is consistent with the stated intent of the subtraction method.

Table 1. Example of RSC Values Calculated by the Subtraction Method

Exposures	**ug/day**
RfD-supported	200
drinking water	20
fish/shellfish	30
all other foods	80
air (inhalation)	0
RSC	**%**
Method GAO 2011	(200-80)/200 = 60%
Method EPA 2015	(200-20-30)/200 = 75%

The Percentage Method

EPA's 2000 HHWQC guidance (EPA 2000) does not contain an equation for calculating the RSC using the percentage method. Rather it is described as: "the percentage of total exposure typically accounted for by the exposure source for which the criterion is being determined, . . . applied to the RfD to determine the maximum amount of the RfD 'apportioned' to that source."

Both GAO 2011 and EPA 2015b contain descriptions of the calculation procedure. These are summarized below:

The example described in GAO 2011 (for drinking water) is:

1. calculate the relative proportion of exposure from water as a percent of the total observed exposure and then
2. apply that percentage as the relative source contribution

The example described in EPA 2015b is:

1. sum the exposure from drinking water and fish/shellfish, and then
2. divide by the total of all know exposures

The two descriptions of the percentage method appear to be the same, that is: (drinking water+fish/shellfish exposure)/(total exposure). Using this equation, the data in Table 1 would yield a RSC value of (20+30)/(20+30+80) = 38%.

There are two noteworthy observations about the percentage method. First is that the equation does not include, and thus is unrelated to, the RfD. Second is that as the proportion of exposure due to drinking water+fish/shellfish decreases relative to the total exposure, the RSC gets smaller. The latter outcome appears counterintuitive relative to the justification for using RSC values in deriving HHWQC.

Discussion

EPA descriptions of the subtraction method, and at least one example of its application, indicate that the intent of the method is to ensure that the RfD is not exceeded. This is accomplished by allocating only the residual part of the exposure after non-drinking water+fish/shellfish exposures are removed. The subtraction method would allocate the entire RfD via this procedure absent EPA's existing policy to cap the RSC at 80%. Intrinsic to the subtraction method, is that as the relative exposure from other (i.e., non-drinking water+fish/shellfish) sources increases, the RSC value decreases in a manner such that the RfD value is never exceeded.

In contrast to the subtraction method, the percentage method is not linked to the RfD. This creates two important distinctions between RSCs calculated using the two methods. These are illustrated in the examples shown in Table 2. One of these relates to situations where the total exposures are well below the RfD-supported exposure and the drinking water+fish/shellfish contribution is small relative to other exposures (first grey highlighted row). In this case the percentage method calculates a very small RSC when this would seem not to be justified in the context of ensuring that the RfD is not exceeded. The implication appears to be one of ensuring that low exposures remain low irrespective of health risk.

Table 2. Examples of RSC Values Calculated by the Percentage and Subtraction Methods

RfD-supported Exposure	Water + Fish Exposure	Other Exposures	RSC, Percent method	RSC Subtrctn. Method	Total exposure before RSC	Allowed exposure after RSC (% method)[a]	Allowed exposure after RSC (Subtrctn. Method)a
100	5	90	0.05	0.10	95	95	100
100	5	50	0.09	0.50	55	59	100
100	50	5	0.91	0.95	55	96	100
100	90	5	0.95	0.95	95	100	100
100	90	50	0.64	0.50	140	114	100
100	50	90	0.36	0.10	140	126	100

[a] calculated as RfD*RSC+Other Exposures

The other distinction between the two methods is that the subtraction method always provides that the RfD is never exceeded, while the percentage method does not (see the lower two gray rows in Table 2). In situations where exposures from drinking water+fish/shellfish are a significant proportion of the RfD-supported exposure and exposure from other sources is also significant, the percentage method allows the total exposure after the application of the RSC to exceed the RfD-supported exposure. As such, the disconnect between the percentage method and the RfD can lead to exposures greater than the RfD.

References

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