Methodology for Evaluating Encapsulated Beneficial Uses of Coal Combustion Residuals

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Office of Solid Waste and Emergency Response
Office of Resource Conservation and Recovery

Disclaimer:

This document describes a methodology designed for use by the Environmental Protection Agency ("EPA" or "the Agency") Office of Solid Waste and Emergency Response (OSWER) that also may be useful and helpful to the states, tribes, local governments, the public, and the regulated community. The approaches outlined in this document are voluntary, not regulatory. They do not change or substitute for any statutory or regulatory provisions. This document presents OSWER's evaluation methodology for encapsulated beneficial uses of coal combustion residuals based on OSWER's current understanding on a range of issues and circumstances involving the encapsulated beneficial use of coal combustion residuals. This document does not impose legally binding requirements, nor does it confer legal rights, impose legal obligations, or implement any statutory or regulatory provisions. Those using this document are free to use and accept other technically sound approaches.

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Abbreviations

CCR	Coal Combustion Residual
COPC	Constituent of Potential Concern
EPA	Environmental Protection Agency
HEI	Highly Exposed Individual
LEAF	Leaching Environmental Assessment Framework
OSWER	Office of Solid Waste and Emergency Response

1 Introduction

1.1 Background

Coal combustion residuals (CCRs) are the byproducts resulting from coal combustion that are captured from plant effluent and flue gases prior to discharge to the environment. Over a hundred million tons of CCRs are generated each year in the United States alone. Once generated, CCRs may either be disposed of or beneficially used. Beneficial use, as defined in this document, is the reuse of CCRs in a product that provides a functional benefit; that may replace a product made from virgin raw materials (referred to as an 'analogous product' or 'analogous non-CCR product') on the market, thus conserving natural resources that would otherwise need to be obtained through practices, such as extraction; and that meets relevant product specifications and regulatory standards.

1.2 Purpose

The primary purpose of this document is to present an evaluation methodology developed by the Environmental Protection Agency ("EPA" or "the Agency") Office of Solid Waste and Emergency Response (OSWER) for determining whether environmental releases from encapsulated products containing CCRs are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors, during use by the consumer.[1] Encapsulated CCR products that meet this criteria are considered to be appropriate beneficial uses.

1.3 Scope

This document describes the evaluation methodology developed by OSWER for determining whether environmental releases from encapsulated beneficial uses of CCRs are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors, during use by the consumer. As discussed in this document, OSWER's evaluation methodology considers several approaches for evaluating encapsulated beneficial uses of CCRs, including a comparison of constituents of potential concern (COPC) concentrations in releases from CCR beneficial use products to those in releases from analogous products that they replace and the evaluation of potential risks that a CCR beneficial use product could pose if COPCs are released at levels that are not comparable to or lower than those found in analogous products. Encapsulated beneficial uses are those that bind

[1] While this methodology may potentially be used to evaluate encapsulated beneficial uses of other, non-hazardous industrial residuals, the focus of this document is encapsulated beneficial use of CCRs.

the CCRs into a solid matrix that minimizes their mobilization into the surrounding environment. Examples of encapsulated uses include, but are not limited to:

- Filler or lightweight aggregate in concrete
- A replacement for, or raw material used in production of, cementitious components in concrete or bricks
- Filler in plastics, rubber, and similar products
- Raw material in wallboard production

Evaluation of unencapsulated uses often requires additional, site-specific considerations and is not addressed by this methodology.[2] Furthermore, this methodology does not address any phase of the product's lifecycle other than use by the consumer.

[2] OSWER's conceptual model for evaluating unencapsulated uses of CCRs is expected to be completed by the second quarter of 2014.

2 Methodology

This section of the document describes the evaluation methodology developed by OSWER for determining whether environmental releases from the encapsulated beneficial use of CCRs are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors, during use by the consumer. The methodology presented in this document has undergone an independent external letter peer review. A summary of the comments received from peer reviewers is available in the document, *Peer Review Summary Report: Independent External Peer Review of the Preliminary Draft Report, Methodology for Evaluation Encapsulated Beneficial Uses of Coal Combustion Residuals* (U.S EPA, 2012). Responses to these comments are available in the document, *Responses to External Peer Review Comments: Methodology for Evaluating Encapsulated Beneficial Uses of Coal Combustion Residuals* (U.S. EPA, 2013).

This methodology is intended to be flexible to allow evaluation of the range of possible encapsulated beneficial uses for any CCR. The evaluation process is divided into five steps. As developed, the party conducting the evaluation can choose to begin at the first step and follow the methodology in the order presented or, based on the type and amount of data available on the CCR and the beneficial use product, can choose to begin the evaluation at any step of the methodology. If all releases from the beneficial use are found to be comparable to or lower than those from an analogous non-CCR product, or to be at or below relevant regulatory and health-based benchmarks, during the evaluation at any step of the methodology, then no further evaluation is necessary.

The party conducting the evaluation should determine how best to apply the methodology to a specific beneficial use product; however, all assumptions and data sources relied upon in the evaluation should be fully documented, explained, and disclosed in the text of the evaluation document. In addition, the party conducting the evaluation is encouraged to engage with the appropriate regulatory organizations to ensure that application of the methodology is consistent with any relevant State beneficial use requirements. The methodology outlined in this document is voluntary, not regulatory, and is not a replacement for existing requirements for beneficial use determinations. The evaluation methodology is discussed in detail in the following subsections and illustrated in **Attachment A**.

2.1 Step 1 – Literature Review and Data Collection

This step of the methodology involves collecting and reviewing available literature on the beneficial use of a CCR. The purpose of this step is twofold. The first purpose is to establish whether existing evaluations, such as technical standards previously developed by voluntary

consensus standard organizations; beneficial use determinations previously made; regulations previously enacted; or scientific studies previously conducted, appropriately demonstrate that releases from the CCR beneficial use under evaluation are comparable to or lower than those from an analogous product, or are at or below relevant regulatory and health-based benchmarks. The second purpose is to collect data on the COPCs present in and released from the CCR beneficial use product under evaluation that were not sufficiently addressed by existing evaluations.

First, a review of the lines of evidence provided in the existing evaluations should be conducted to determine if the available information, considered as a whole, accurately reflects the CCR beneficial use under evaluation, and is of sufficient quality to support the conclusions presented. The review should examine each existing evaluation based on the type, amount, and quality of data, as well as the methods of analysis.[3] If the review finds a given voluntary technical consensus standard or other type of existing evaluation to be of sufficient applicability and quality to demonstrate that releases from the CCR beneficial use under evaluation are comparable to or lower than those from an analogous product, or are at or below relevant regulatory and health-based benchmarks, then no additional evaluation is necessary. However, if the existing evaluations do not support such a finding for either the CCR beneficial use product as a whole or for individual COPCs associated with the CCR beneficial use product, then further evaluation is necessary.

Second, if additional evaluation is warranted, the available literature should be reviewed for data pertaining to the identity of the COPCs, the range of COPC concentrations that may be present in the CCR and beneficial use product, and the rate at which the COPCs may be released into the surrounding environment. The data collected will be used throughout the remainder of any necessary evaluation steps. This methodology is iterative in order to account for the fact that the exact type and amount of data needed to complete the evaluation may not be known at first. The type and amount of data needed is dependent in part on the variability and quality of the available data. If at any point in the evaluation it is determined that additional data are required, the evaluation may collect the needed additional data and work through the appropriate steps again with the newly collected data incorporated into the dataset. Regardless of the number of iterations performed, it is only necessary to document the final iteration through the relevant steps of the methodology.

Data collection efforts initially focus on identification of the COPCs that are associated with CCRs. These are the COPCs that the CCRs either directly add to the beneficial use product or cause to be released at higher rates due to their incorporation in the product. Data previously

[3] The document, "A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information" (U.S. EPA, 2003a) summarizes the general assessment factors used by EPA to evaluate the quality of the data that is submitted to or gathered by the Agency.

collected by EPA, generators, trade associations, or peer-reviewed publications may provide a good foundation for identifying the types and concentrations of these COPCs in the CCRs. Once the COPCs relevant to the CCR(s) under evaluation have been identified, data should be collected on the different routes through which these COPCs may be released into the environment from the beneficial use product. Releases may result from any biological, chemical, or physical process that acts to mobilize constituents away from the encapsulated matrix of the product. If sufficient data are available to demonstrate that the product is unlikely to be exposed to any processes that may mobilize COPCs, then the CCR beneficial use product may be considered comparable to analogous non-CCR products and no further evaluation is necessary.

If sufficient data are not available to reach a determination, then existing data may be supplemented by further characterizations conducted for the purposes of the evaluation. The "Characterizing Waste" chapter of the *Guide for Industrial Waste Management* provides examples of some potentially appropriate leaching characterization methods (U.S. EPA, 2003b).[4] When collecting and evaluating data, care should be taken to ensure that the appropriate method(s) be used in generating the final dataset so as to reflect the range of environmental conditions relevant to the CCR beneficial use product.

Uncertainties remaining in the dataset following data collection may be addressed with conservative simplifying assumptions, as long as these assumptions properly reflect the full variability of the products. However, all assumptions and uncertainties present in the evaluation should be fully documented, explained, and disclosed. COPCs that have not been shown in existing evaluations to be comparable to or lower than those from an analogous product, or to be at or below relevant regulatory and health-based benchmarks, and that have the potential to be released to the environment, should proceed to the next step of the methodology. In addition, corresponding data on those COPCs retained for further evaluation should be collected for analogous products and raw materials that the beneficial use product and CCR replace.

Hypothetical Application of Step 1

During review of the available literature, it is discovered that an international health agency has previously studied the leaching behavior of three COPCs from a number of commercial products, including the CCR beneficial use product under evaluation. The study found that even the highest leachate concentrations observed from the CCR beneficial use product did not result in unacceptable risks from contaminated ground water and surface water. A thorough review of the study identifies no significant data gaps or other concerns. Based on these findings, the

[4] Note that the leachate characterization methods presented in this guide all evaluate samples at a single pH value. In contrast, the Leaching Environmental Assessment Framework (LEAF) was developed specifically to allow evaluation of leaching potential over the range of leaching conditions expected to occur. The LEAF methods have undergone inter-lab validation in the United States and have been incorporated into the EPA SW-846 analytical methods, available on the EPA website at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/new_meth.htm.

leaching of these three COPCs would not need further evaluation. However, if there are additional release routes for these three COPCs other than leaching, or if there are additional COPCs associated with leachate from the CCR beneficial use product other than these three, then the additional release routes and COPCs that are not sufficiently addressed by the existing literature would remain to be addressed in subsequent steps of the evaluation.

2.2 Step 2 – Comparison of Available Data

Step 1 of the methodology previously identified the COPCs associated with the CCR beneficial use product and the routes through which they may be released. This step involves a comparison of data carried forward from the previous step. The purpose of Step 2 is to determine whether COPC releases from the beneficial use product are comparable to or lower than those from an analogous product. This comparison requires that the beneficial use product and analogous product have at least one COPC and corresponding release route in common, as concentrations of COPCs released to different media are not directly comparable. The remainder of this step pertains to these common releases only. Evaluation of any COPCs or release routes unique to the beneficial use product should proceed directly to the next step of the methodology. If the COPC concentrations in releases from the CCR beneficial use product are found to be comparable to or lower than those from an analogous product, then no further evaluation would be necessary, at least for those COPCs that meet this criteria.

It may not be necessary to compare releases from the products as a whole. A given product may be composed of multiple different raw materials. If the same raw materials are used in the CCR beneficial use product and the analogous product in similar proportions, it may be appropriate to compare only the releases that result from the portion of the products that are replaced by the CCRs. For example, if the only change made to an analogous product is replacement of one raw material with a CCR, then all of the remaining raw materials would be the same between the CCR beneficial use product and the analogous product. If replacement of this one raw material with the CCR does not alter releases of COPCs from the CCR or the remaining raw materials, then it would be appropriate to compare only the releases of COPCs that result from replacing the raw material with the CCR. However, physical or chemical changes that occur during the production process may fundamentally change the properties of the CCR beneficial use product such that it would alter releases of the COPCs from either the CCR or the remaining raw materials. Therefore, sufficient information is needed to demonstrate that data on releases of COPCs from the CCR are representative of the resulting product.

Based on the type and amount of data available, it may be appropriate to use a surrogate in place of releases in the comparison of the CCR beneficial use and analogous products. For the purposes of this methodology, a surrogate is data on one variable that can be used to reliably approximate the behavior of another variable and, as a result, can substitute for the other variable in the comparison. Any variable can be used as a surrogate, so long as a clear relationship

between the surrogate and the COPC releases can be documented. For example, if the literature shows that there is a consistent linear increase in releases of a COPC from both the CCR beneficial use product and analogous products with increasing concentrations of the COPC in these products, then the concentration of the COPC in the products may be used as a surrogate for releases of the COPC in the comparison. However, it is important to note that use of a surrogate introduces some additional uncertainty into the evaluation because the surrogate only approximates the magnitude of actual releases from the products. A discussion of uncertainties associated with the surrogate should be provided.

The comparison of COPC releases needs to account for each release route, as well as the full range of either the COPC concentrations that may be present in those releases or an appropriate surrogate. This may be accomplished using statistical analysis, if sufficient data are available, or another appropriate comparison method. One example of statistical software that may be used to assist with comparison of two datasets is ProUCL.[5] If the comparison demonstrates that the COPC concentrations in releases from the beneficial use product are comparable to or lower than those from an analogous product, then no further evaluation is necessary. However, if the COPC concentrations associated with one or more release routes are not comparable to or lower than those from an analogous product, evaluation of those COPC releases should proceed to the next step of the methodology.

Hypothetical Application of Step 2

A beneficial use product under evaluation contains a COPC that can volatilize and enter the ambient air. The same COPC and release route is also present in the analogous product. Available literature shows a strong relationship between the concentration of this COPC in the products and the emission rate from the product. Therefore, the change in emission will be driven primarily by changes in the concentration of the COPC present in the products. Based on these findings, it is appropriate to conduct a comparison of concentrations of the COPC. A statistical test conducted on the range of COPC concentrations reveals there is no significant difference between the concentrations in the two products. Based on these findings, releases of the COPC to the air would not require further evaluation.

2.3 Step 3 – Exposure Review

This step of the methodology involves development of a conceptual exposure model for each COPC and corresponding release route carried forward from the previous steps. A conceptual exposure model qualitatively illustrates the four components of a complete exposure pathway.

[5] ProUCL is a software package developed by EPA to assist with statistical analysis. This program can perform many statistical functions on data sets, both with and without non-detect values. The model is available on-line at: http://www.epa.gov/osp/hstl/tsc/software.htm

All four of these components must be present at either the time of release or at some future time in order for a complete exposure pathway to exist. Otherwise, receptor exposures to COPCs are not possible. These components include the COPCs present in the product, the routes through which these COPCs may be released from the product, the routes through which receptors may be exposed to the COPCs in the environment, and the types of receptors that may be exposed. The previous steps of the methodology identified the COPCs that may be present in the beneficial use product and the routes that they may be released into the environment. The purpose of this step is to characterize the potential exposure routes and receptor types for use in subsequent steps. If receptors are unlikely to be exposed to any of the COPCs released from the CCR beneficial use product, then the CCR beneficial use product is considered comparable to analogous non-CCR products and no further evaluation is necessary.

Exposures result from contact between a receptor and a chemical or physical agent. Exposure may occur through a variety of routes, such as ingestion, inhalation, or dermal contact. The types of exposures possible are dictated primarily by the media (e.g., air, water) in which the COPC is released. Receptors may be exposed to the same COPC through multiple exposure routes. Each of the potential exposure routes should be captured in the conceptual exposure model. Persistence of a contaminant in the environment may also be an important consideration for some COPCs. If a COPC degrades faster than it can be transported through the environment, it will not reach receptors and exposures will not occur.[6]

Receptors can be divided into two general categories, human and ecological. Human receptors can be further subdivided based on the location of exposure (e.g., office, residence), which then informs the possible age of the receptor (e.g., adult, child). For example, in an office setting, it is likely that adults would be the relevant population, whereas in a residential setting, both adults and children would be the relevant population. Ecological receptors may be subdivided based on taxonomic grouping (e.g., mammal, bird, fish), trophic level (e.g., primary, secondary), and habitat (e.g., aquatic, terrestrial). The conceptual exposure model should accurately capture the most relevant potential receptor types based on different physical characteristics (e.g., body mass) and behavioral characteristics (e.g., ingestion rates) of the receptors that affect the magnitude, frequency, and duration of the resulting exposures. These receptors may be exposed at the time of the release or may be exposed at some future time. Therefore, the conceptual model should capture both the potential current and hypothetical future receptors.

The COPCs and release routes identified in the previous steps, as well as the exposure routes and receptors identified in this step can then be depicted in a conceptual exposure model. The conceptual exposure model may take the form of one or more figures, depending on how it is

[6] The PBT Profiler screens chemicals for the potential to persist in the environment, to bioaccumulate, and to be toxic. The model is available on-line at: http://www.epa.gov/oppt/sf/tools/methods.htm.

easiest to present the information. Data may not be needed for every receptor type identified. For each complete exposure pathway, evaluation of only the highly exposed individuals (HEIs), hypothetical human receptors subjected to reasonable high end exposures, and the ecological receptors determined to be most sensitive to the COPCs may be sufficient. The HEI and sensitive ecological receptor may not be the same for every COPC or exposure route. Evaluation of the complete exposure pathways identified in this step should proceed to the next step of the methodology.

Hypothetical Application of Step 3

A beneficial use product is used as a building material. The CCR beneficial use product contains three inorganic COPCs present at levels higher than the analogous product. One of these COPCs may volatilize and migrate into indoor air, where receptors may inhale the COPC. All three COPCs may leach when exposed to rainfall, which may then migrate to ground water and, subsequently, to downgradient surface water bodies. The exposed surfaces of the product are polished to a smooth finish prior to use and, therefore, dust generation is not anticipated during intended use.

The conceptual exposure model for this hypothetical example is presented in **Figure 2-1**. The dashed lines denote pathways or receptors that, while considered, were determined to not result in the highest exposures and were not carried forward for further evaluation. Residential receptors are determined to be the HEIs for this evaluation, while invertebrates are found to be the most sensitive class of ecological receptors to these three COPCs.

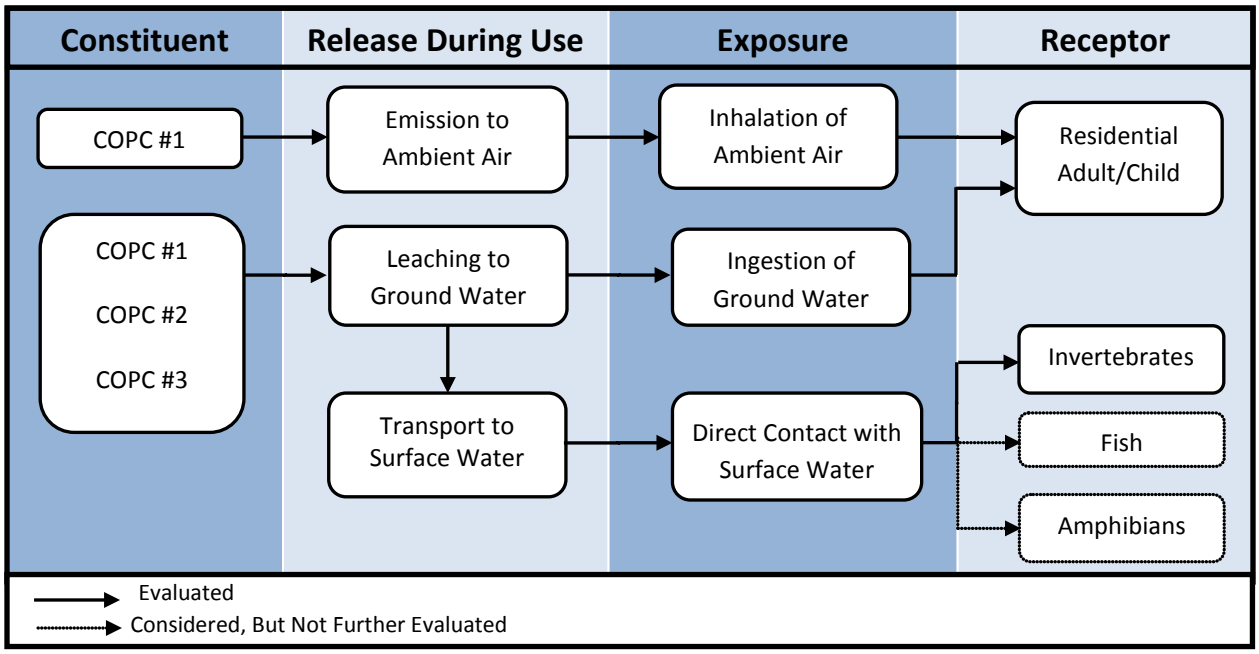

Figure 2-1: Generic Conceptual Exposure Model for Human and Ecological Receptors

2.4 Step 4 – Screening Assessment

This step of the methodology involves a conservative comparison of the COPCs, carried forward from previous steps, to appropriate regulatory or health-based screening benchmark. This is accomplished using conservative data and assumptions on environmental conditions present, fate and transport of the COPCs, and/or receptor exposures. These data and assumptions are combined with available data on COPC releases to calculate COPC concentrations at the point of exposure. The resulting conservative exposure point concentrations are then compared to screening benchmarks. Appropriate screening benchmarks may already be defined by state or federal legislation, regulations, or existing risk management policy. One example of potentially appropriate existing set of screening benchmarks is the ecological screening benchmarks available on EPA's Region 3 website.[7] Screening benchmarks may also be calculated by the party conducting the evaluation. In all cases, it is important to understand and disclose all of the assumptions behind each set of screening benchmarks to ensure that they are appropriately conservative.

For some COPCs, available data on the potential adverse effects for human or ecological receptors may be insufficient to develop screening benchmarks. In these instances, it is not possible to conduct a comparison to screening benchmarks or subsequent calculation of risk in Step 5. This lack of quantitative toxicological information constitutes a data gap, adding to the uncertainty of the evaluation. The uncertainty surrounding this data gap should be discussed qualitatively using the available knowledge on the COPC. This discussion should describe the possible influence that these uncertainties may have on the final conclusions.

Initially, COPC concentrations at the point of release may be used in place of the concentrations at the point of exposure and compared directly to applicable screening benchmarks. This comparison assumes that receptors are exposed directly to the COPCs as they are released from the CCR beneficial use product. For some direct exposures to releases, such as incidental ingestion of dust from the product, this comparison may accurately represent potential exposures. For other indirect exposures to releases, such as ingestion of leachate that has migrated through ground water, it would provide a very conservative comparison.

COPCs found to exceed screening benchmarks at the point of release should be carried forward for additional evaluation. Where appropriate, the concentration of these COPCs may be adjusted to conservatively account for dilution and attenuation that may occur in the environment prior to receptor exposure. This may be accomplished with conservative environmental data, fate and transport assumptions, and/or exposure assumptions applied to either established factors documented in the literature or fate and transport modeling. The "Protecting Air" and "Assessing

[7] Ecological screening benchmarks for COPC concentrations in surface water and sediment in both freshwater and marine environments are available on-line at: http://www.epa.gov/reg3hwmd/risk/eco/index.htm

Risk" chapters of the *Guide for Industrial Waste Management* (U.S. EPA, 2003b) and the "An Overview of Exposure Assessment Models Used by the US Environmental Protection Agency" chapter of *Modeling of Pollutants in Complex Environmental Systems, Volume II* (Williams et al., 2010) both provide examples of models that may be used to account for fate and transport through the environment. Different models are designed with varying scopes and levels of specificity. Care should be taken to ensure that any model selected appropriately reflects the potential transport and exposure scenarios under consideration and that the required input data are available. If all COPC concentrations are found to be at or below screening benchmarks at either the point of release or exposure, then no additional evaluation is necessary. However, if one or more COPCs exceed the associated screening benchmarks at the point of exposure, then evaluation of those COPCs should proceed to the next step of the methodology.

Hypothetical Application of Step 4

A beneficial use product under evaluation has been shown to contain a single COPC that is not also present in comparable levels in an analogous product. The only complete exposure pathway identified for this COPC is ingestion of contaminated ground water. Of the potential receptors identified, residential receptors are determined to be the HEIs. Conservative health-based screening benchmarks are calculated from exposure factors relevant to these receptors from the 2011 Exposure Factors Handbook (U.S. EPA, 2011).

The COPC concentration measured at the point of release is found to exceed the screening benchmark for residential receptors. (Note: If the COPC concentration measured at the point of release does not exceed the screening benchmark for residential receptors, then no further evaluation would be needed.) As a result, the Industrial Waste Management Evaluation Model is selected to adjust the COPC concentration based on dilution and attenuation in the environment (U.S. EPA, 2002). Some conservative assumptions incorporated into the model are that the soil is highly permeable and that the closest residential receptors live directly adjacent to the source of the ground water. A comparison of the modeled COPC concentration at the point of exposure to screening benchmarks shows that the COPC is now below all relevant screening benchmarks. Based on these findings, exposures to leaching of this COPC would not require further evaluation. However, if the COPC concentration at the point of exposure had exceeded the relevant screening benchmarks, then the evaluation would proceed to the next step of the methodology.

2.5 Step 5 – Risk Assessment

This step of the methodology involves quantitative and qualitative evaluation of the risks associated with COPC exposures carried forward from the previous steps. The purpose of this step is to determine whether the CCR beneficial use product may result in unacceptable risk to

human or ecological receptors. However, this step of the methodology can still be used where insufficient data are available to calculate risks for specific COPCs.

Prior to calculation of risks, it may be appropriate to update the conservative data and assumptions used in Step 4 to generate a more realistic assessment of receptor exposures. This may be accomplished using data and assumptions on the environmental conditions present, the fate and transport of COPCs, and/or receptor exposures that are more representative of real world conditions than those used in Step 4. These data and assumptions are combined with available data on COPC releases to calculate more realistic COPC concentrations at the point of exposure. The party using the methodology may select the method for incorporating these data and assumptions that is most appropriate for the specific evaluation, which may be probabilistic or deterministic, as well as how to best present the results.

Where possible, the evaluation should evaluate risks from each exposure and provide a quantitative characterization of those risks. The "Risk Characterization" chapter of the *Risk Assessment Guidance for Superfund* provides equations that may be used to quantify risks (U.S. EPA, 1989). Where there are insufficient data to calculate risks for specific COPCs, a qualitative characterization of the potential risks based on the available information is appropriate. An important aspect of discussing risks is identifying and analyzing any uncertainties present in the evaluation. Uncertainties may represent a lack of knowledge about factors, such as the adverse effects or COPC concentrations. An uncertainty analysis should discuss the accuracy and precision of the data and models that are relied upon, as well as any existing data gaps, and their impact on the conclusions of the evaluation.

Both state and federal regulatory agencies have established acceptable risk benchmarks within their jurisdiction for many chemicals. Therefore, it is necessary to define the acceptable risk benchmarks for the complete exposure pathways under evaluation. These benchmarks may take the form of a discrete risk level, a risk range, or a maximum allowable concentration in a given media. If the identified risks are found to be at or below the identified risk benchmarks and remaining data gaps and uncertainties are found to be acceptable, then no further evaluation is needed. However, if indentified risks are above acceptable risk benchmarks or existing data gaps and uncertainties are too great to reach a final conclusion, then the CCR product evaluated is not considered appropriate for beneficial use.

Hypothetical Application of Step 5

The previous four steps of the evaluation screened out all complete exposure pathways, except for ingestion of a single COPC in ground water contaminated by leachate from the CCR product. The fifth step begins by reevaluating the conservative assumptions used in the previous screening step and replacing them with more realistic environmental data and fate and transport assumptions. The model used in the previous step is rerun using these modified assumptions to

generate more realistic COPC concentrations at the point of exposure. The adjusted ground water concentrations are then used to calculate the associated cancer and non-cancer risks, rather than comparing to screening benchmarks. However, the resulting risks are still above acceptable risk benchmarks. Therefore, the CCR product evaluated is not considered appropriate for beneficial use.

3 References

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Attachment A

Five Step Beneficial Use Evaluation Flowchart

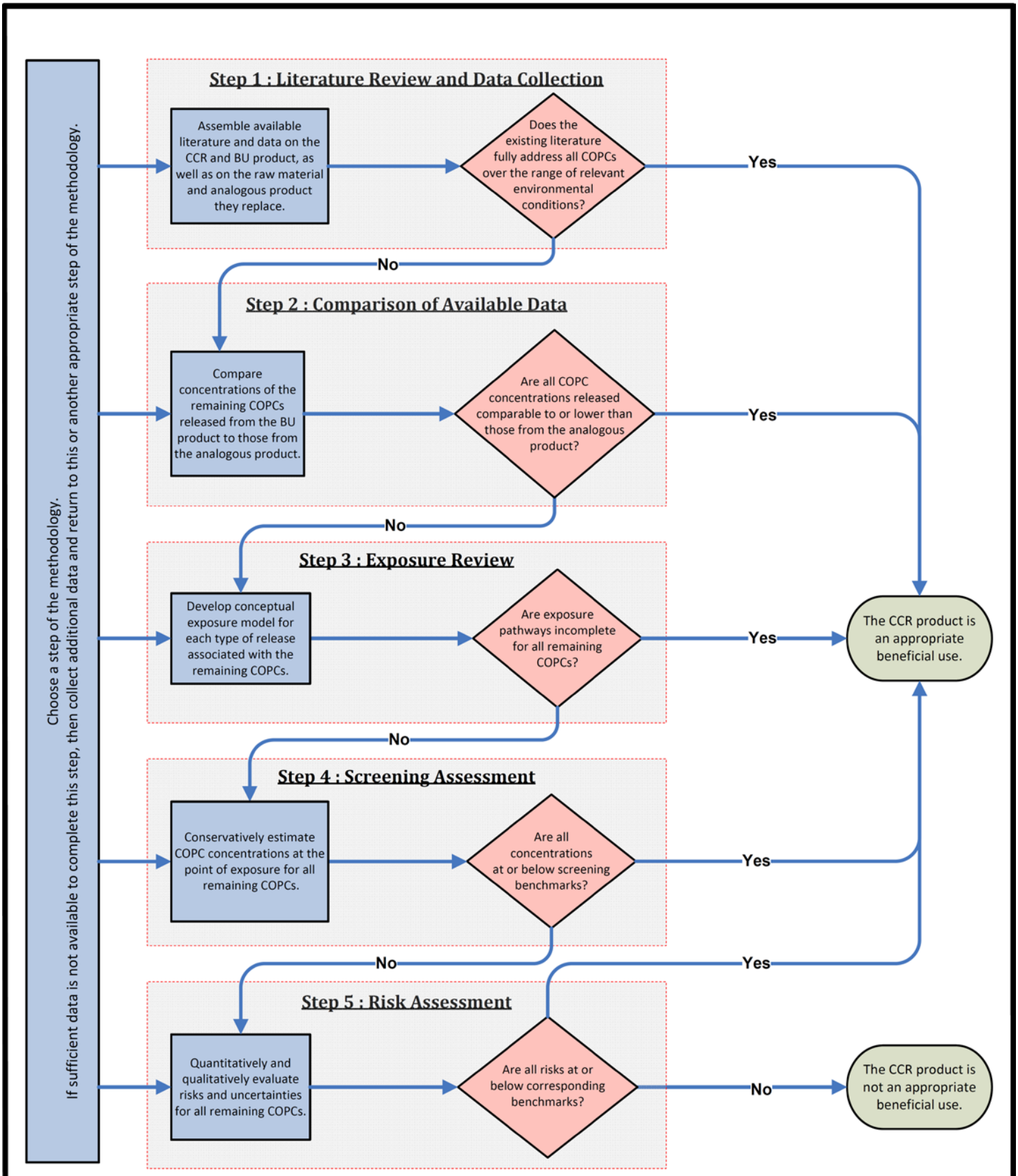

Figure A-1: Five Step Beneficial Use Flowchart

Legend:

BU – Beneficial Use
CCR – Coal Combustion Residual
COPC – Constituent of Potential Concern

EPA530-R-13-005