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MEMORANDUM

To:	Dan Watton – Eversource Elizabeth Tillotson – Granite Shore Power
From:	Patrick Gwinn, Senior Consultant Russell Keenan, Ph.D., Vice President / Principal
Date:	June 20, 2019
Subject:	Integral Review Findings of the June 14, 2019 GZA Report on Post-Demolition Building Surface Sampling and Evaluation of Human Health Risk, Former Schiller Station Mercury Power Generating Units 1 and 2, Portsmouth, New Hampshire
Project No.:	C1857

In accordance with our March 6, 2019 proposal to provide risk assessment consultative support for the Schiller Station mercury boiler dismantling project, Integral Consulting Inc. (Integral) has reviewed the June 14, 2019 GZA report, *Report on Post-Demolition Building Surface Sampling and Evaluation of Human Health Risk, Former Schiller Station Mercury Power Generating Units 1 and 2, Portsmouth, New Hampshire* (hereafter referred to as the GZA HHRA[1]). This technical memorandum provides a summary of our review findings and conclusions on whether the GZA HHRA adequately characterizes the potential for human exposures to residual mercury, and the risks associated with the potential exposures.

Consistent with our proposal, we evaluated the completeness of the GZA HHRA by assessing the extent to which it provides information on the following basic building blocks of a human health risk assessment:

- Hazard Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

[1] HHRA – human health risk assessment

- Uncertainty Evaluation

In addition, we evaluated the methods, assumptions, and calculations employed in the GZA HHRA to arrive at a conclusion as to whether the GZA HHRA can be relied upon for evaluating future worker safety relative to potential exposure to post-demolition residual mercury.

A discussion of each of the human health risk assessment components follows.

Hazard Identification

Hazard identification is the process of identifying the type of hazard to human health posed by the exposure of interest for a given risk assessment. Hazard identification for most risk assessments focuses on chemical agents. Chemical agents are a subset of all stressors (e.g., chemical, biological, social or physical) (USEPA 2014).

The GZA HHRA identifies the potential hazard as mercury, present as a residual after the dismantling of two mercury boilers and subsequent surface cleaning. The GZA HHRA identifies three media that may contain residual mercury – indoor air, porous surfaces (e.g., concrete or brick), and non-porous surfaces (e.g., steel beams, etc.).

The GZA report states that the mercury is expected to be predominantly in elemental form because the mercury boilers relied on elemental mercury. This is a reasonable assumption to employ in the risk assessment. However, for certain exposure scenarios, the GZA HHRA also evaluates mercury as a mercury salt (e.g., $HgCl_2$ – or mercuric chloride).

It is our opinion that any residual mercury from the boilers is likely to be in the elemental form, but evaluating it as mercuric chloride is appropriate and tends to result in a conservative or health protective assessment.[2]

Exposure Assessment

Exposure assessment is one of the primary components of risk assessment; it describes how humans may come into contact with hazards. The exposure assessment is an outcome of the conceptual site model and considers the following:

- Receptor populations

[2] The use of the term "conservative" in this technical memorandum implies that the subject being discussed tends to result in a more health protective assessment.

- Sources, pathways, and routes of exposure, and determining an approach for consideration of multiple exposure pathways, if relevant
- Descriptors of exposure, generally including estimates for "average" and "high-end" exposures
- Data and methods used in developing the exposure estimates

The GZA HHRA identifies an adult industrial worked as the receptor population. Given the nature of the facility and location of the residual mercury evaluated, this is an appropriate receptor population.

The GZA HHRA identifies the potential sources of mercury as the porous and non-porous surfaces that may contain residual mercury. The exposure pathways that are evaluated include inhalation of mercury in indoor air, dermal uptake of mercury from contact with non-porous and porous surfaces, and incidental ingestion of mercury that adheres to the hands. The exposure pathways identified in the GZA HHRA are the appropriate ones for evaluating potential exposure to an industrial worker.

The exposure parameters used in quantifying each exposure pathway in the GZA HHRA are appropriate and conservative. For example, the worker receptor is assumed to work at the facility and contact the various media every work day for 25 years. Further, the frequency of exposure is 8 hours per day, 250 days per year for inhalation exposures, and 8 exposure episodes (dermal and ingestion) per day, 250 days per year for non-porous surfaces. While certain exposure parameters, such as body weight, used in the GZA HHRA differ from the current U.S. Environmental Protection Agency (USEPA) default values, the values used in the GZA HHRA are more conservative than USEPA defaults and, therefore, still appropriate.

The data used in the GZA HHRA to evaluate inhalation of mercury in indoor air results from direct measurement of mercury levels in indoor air. The more than two years of continuous data monitoring data are more than adequate to assess potential future inhalation exposures. The GZA HHRA's use of all air sampling data is conservative in light of the decrease in mercury vapor concentration noted since the completion of the boiler dismantling. The use of all data will likely overestimate potential future exposures.

The models used to assess dermal uptake and incidental ingestion of mercury from contact with porous surfaces are not from a standard risk assessment guidance document. However, the models are derived from equations published in a peer-reviewed journal article and subsequently modified for metals by personnel at the California Department of Toxic Substances Control. The exposure models provide reasonable estimates of potential exposure to metals, such as mercury, from incidental contact with non-porous surfaces.

The GZA HHRA evaluates mercury exposure from porous surfaces indirectly. That is, the exposure is assumed to occur due to airborne emissions of mercury from the porous media with subsequent inhalation. In our opinion, this approach is inferior to the direct inhalation assessment using the air monitoring data, and greatly exaggerates the exposure from porous media.[3] Nevertheless, the use of this exposure pathway for mercury in porous media, while implausible, is conservative and does not underestimate potential risk.

The exposure assessment in the GZA HHRA results in an assessment of potential exposure that is appropriate, if not conservative, for the assessment of risks for future industrial workers.

Toxicity Assessment

The toxicity or dose-response assessment examines the numerical relationship between exposure and effects. In the GZA HHRA, the toxicity assessment takes the form of selecting risk-based screening levels for each exposure medium and pathway. For example, to assess risks associated with potential inhalation exposures, the GZA HHRA selects the USEPA commercial worker air (inhalation) regional screening level (RSL). While the GZA HHRA states that the RSL is to assess elemental mercury, mercuric chloride and other mercury salts, the RSL is based on the non-cancer reference concentration (RfC) for elemental mercury developed by USEPA and reported on their Integrated Risk Information System (IRIS). The IRIS RfC for elemental mercury is considered a Tier 1 toxicity value, meaning it has undergone extensive evaluation by USEPA and has been published in IRIS for use in risk assessments. The use of the commercial worker air RSL to assess the potential hazards associated with inhalation of indoor air is appropriate for this assessment.

For the evaluation of dermal and incidental ingestion of mercury from non-porous surfaces, the GZA HHRA uses a Tier 1 oral reference dose (RfD) for mercuric chloride and other mercury salts. The GZA HHRA acknowledges that an oral RfD for elemental mercury, the form most likely present, would be most appropriate, but it does not exist. The GZA HHRA acknowledges that the oral bioavailability of elemental mercury is very low compared to mercuric chloride. As a result, the use of the oral RfD for mercuric chloride to assess dermal and incidental ingestion of mercury from non-porous surfaces is likely to be

[3] The exaggeration of exposure for the porous media is demonstrated by an evaluation of the risk-based regional screening level (RSL) used to evaluate this pathway. For example, according to the RSL model, nearly 60% of the mercury exposure from the porous media as evaluated in the GZA HHRA is assumed to originate as the result of particles entrained by wind blowing at roughly 10 mph and that the source of the particles is infinite. Given that the evaluation is of an indoor work environment, this scenario is not plausible.

conservative. The use of the RfD for mercuric chloride and other mercury salts is used in the derivation of the risk-based screening value for mercury in wipe samples.

Finally, to assess the potential hazards that may arise from exposures to mercury in porous media, the GZA HHRA relies on a USEPA worker RSL for elemental mercury in soil. This RSL relies on the same elemental mercury RfC used in the GZA HHRA to evaluate the air monitoring data. The GZA HHRA uses the RSL for elemental mercury in soil because it is the lowest RSL for the various forms of mercury, so in that sense it is conservative. However, as we described above, a more appropriate mercury inhalation evaluation is conducted when assessing the indoor air monitoring data. Nevertheless, the assessment of mercury in porous media can be used as a very conservative secondary line of evidence.

It is our opinion that, given the toxicological data that are available for the various forms of mercury, the GZA HHRA uses values that result in a conservative assessment of each exposure pathway. Moreover, the use of Tier 1 toxicity values in the GZA HHRA adds strength to the assessment.

Risk Characterization

The risk characterization presented in the GZA HHRA is different than a traditional noncancer risk assessment. In traditional risk assessment, the exposure media concentration data and exposure assessment information are combined to yield an average daily chemical dose. The average daily dose is then compared to the toxicity values to determine whether average daily dose is above or below the toxicity value.

The GZA HHRA uses the same components as a traditional noncancer risk assessment, but compares the exposure media concentration data to a risk-based concentration threshold that is derived from the exposure assessment and toxicity values under the assumption that the average daily dose is equal to, but not greater than, the toxicity value. If, on average, the exposure media data are lower than the risk-based concentration thresholds, then it is appropriate to conclude that the modeled exposures are not likely to pose an unacceptable risk. The logic supporting this approach is sound and appropriate.

The GZA HHRA concludes that, on average, the concentration of mercury measured in the indoor air over the entire monitoring period is lower than the RSL of 1.3 $\mu g/m^3$. The hazard quotient (HQ), which is a numeric comparison of the concentration data to the RSL (i.e., the concentration divided by the RSL) is 0.6.[4] Comparing the average concentration of mercury in air measured since the completion of the removal project to the RSL yields an HQ of 0.2.

[4] 0.83 $\mu g/m^3 \div 1.3\ \mu g/m^3 = 0.6$.

Both of these HQs are less than one, indicating that industrial workers are not likely to be at a risk of harm from residual mercury boiler mercury in indoor air over the course of a 25-year term of employment.

For the non-porous media, the GZA HHRA compares the wipe sample results to the risk-based screening value for mercury for non-porous media, 52 μg/cm^2. The HQ associated with non-porous media is 0.05.[5] Based on this HQ, industrial workers are not likely to be at a risk of harm from residual mercury boiler mercury found on non-porous surfaces over the course of a 25-year term of employment.

For the porous media, the GZA HHRA compares the bulk sampling data to the risk-based screening value for mercury for non-porous media, 460 μg/cm^2. The HQ associated with non-porous media is 0.4.[6] Based on this HQ, industrial workers are not likely to be at a risk of harm from residual mercury boiler mercury found on porous surfaces over the course of a 25-year term of employment.

The GZA HHRA also discusses the aggregate hazard index (HI) (termed cumulative hazard index in the GZA HHRA). The aggregate HI is the sum of the exposure media-specific HQs. For this assessment, the worse-case aggregate HI is not greater than one, indicating that exposure to mercury from inhalation of indoor air and contact with porous and non-porous surfaces are not likely to pose a risk of harm to an industrial worker. A more realistic aggregate hazard index is even lower.[7]

Uncertainty Assessment

The GZA HHRA identifies areas of uncertainty throughout the risk assessment, and discusses them appropriately in the context of their effect on the assessment (i.e., being conservative and health protective).

[5] 2.5 μg/cm^2 ÷ 52 μg/cm^2 = 0.05. The concentration value of 2.5 μg/cm^2 is the 90% upper confidence level on the mean of all wipe samples, and is used to represent a conservative estimate of the mean wipe sample concentration.

[6] 162 μg/cm^2 ÷ 460 μg/cm^2 = 0.4. The concentration value of 162 μg/cm^2 is the 90% upper confidence level on the mean of all bulk samples, and is used to represent a conservative estimate of the mean bulk sample concentration.

[7] A more realistic aggregate hazard index uses the post-demolition air monitoring data, which brings the aggregate HI to a value of 0.6 or 0.2, if the current downward trend in air levels is more representative of future conditions.

Conclusions

Based on our review of the GZA HHRA, we conclude that the assessment is a conservative evaluation of potential future worker exposure to residual mercury boiler mercury at Schiller Station. The GZA HHRA adequately characterizes the potential for human exposures to residual mercury and the risks associated with the potential exposures.