THOMAS J. YOUNG
Senior Counsel
JOHN A. LEVEL
WILLIAM R. SHERMAN
KELLY T. WOOD
Assistant Attorneys General
P.O. Box 40117
Olympia, WA 98504-0117
(360) 586-6770
Attorneys for Plaintiff State of Washington

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF WASHINGTON

HANFORD CHALLENGE, UNITED ASSOCIATION OF PLUMBERS AND STEAMFITTERS LOCAL UNION, and the STATE OF WASHINGTON, Plaintiffs, v. ERNEST J. MONIZ, in his official capacity as Secretary, the UNITED STATES DEPARTMENT OF ENERGY, and WASHINGTON RIVER PROTECTION SOLUTIONS LLC, Defendants.	NO. 4:15-cv-05086-TOR (*consolidated with* NO. 4:15-cv-05087-TOR) DECLARATION OF CHARLES HALBERT IN SUPPORT OF PLAINTIFF STATE OF WASHINGTON'S MOTION FOR PRELIMINARY INJUNCTION

I, CHARLES HALBERT, declare under penalty of perjury under the laws of the state of Washington that the following is true and correct.

1. I am over the age of 18, competent to be a witness herein, and make this declaration in that capacity. I state the following based upon my personal knowledge.

2. I have been employed as an Environmental Engineer at Landau Associates for 18 years. I obtained two degrees in Environmental Engineering from the New Mexico Institute of Mining and Technology: a Bachelor of Science degree in 1997 and a Master of Science degree in 1998. I am a Professional Engineer, maintaining active licenses in Washington State (License No. 38931) and Oregon State (Certificate No. 74068PE). Since 2003, I have been responsible for the overall management of Landau Associates' air quality practice.

3. My air quality assessment and permitting experience includes estimating chemical concentrations in exhaust streams or releases from air pollution sources, modeling the effects of chemical migration into indoor spaces, modeling the effects of atmospheric dispersion on air pollutant emissions, comparing the efficacy of air pollution control equipment alternatives for use on sources of air pollutants, and evaluating compliance with regulatory requirements for maximum acceptable ambient air impacts and minimum required engineering control technologies.

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

4. I have been asked by the Washington State Attorney General's Office (State) to provide this declaration in the above-captioned lawsuit. As I understand it, the State has brought a suit against the United States Department of Energy (DOE) and Washington River Protection Solutions, LLC (WRPS), under 42 U.S.C. § 6972(a)(1)(B), on the grounds that chemical vapors released from or near the tank farms at the Hanford site's 200 Area present an imminent and substantial endangerment to human health. I am making this declaration in support of the State of Washington's Motion for Preliminary Injunction. I anticipate reviewing additional records and transcripts of any depositions of DOE and WRPS staff, and producing a full report on air quality issues for this matter, which is due in August of this year. That report is expected to contain additional information regarding potential chemical vapor concentrations to which Hanford workers may be exposed. However, at this early stage of the litigation, I am providing opinions in this declaration as to DOE and WRPS's failure to protect worker health and safety by (1) failing to adequately monitor and characterize source chemical vapor concentrations that can migrate to worker breathing zones, (2) failing to adequately assess the potential for elevated short-term exposure concentrations in worker breathing zones, and (3) failing to use empirical data-in the form of documented worker exposures to

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

chemical vapors-to identify protective vapor control zones (VCZs). My opinions, which are documented in my declaration following statements of fact, are organized according to those three categorical failures.

5. It is my understanding that, in addition to my declaration, three other experts are submitting declarations on related topics: Bruce Miller, an industrial hygiene expert, on DOE's and WRPS's failure to adopt industrial hygiene and occupational health and safety procedures that can protect workers at the Hanford tank farms; Russell Ogle, a chemical engineer, on the mechanisms by which chemical vapors may be released from the tank farms, the possible content of those vapors, and how DOE and WRPS have made and now manage a system that allows their release; and Joyce Tsuji, a toxicology expert, on the health and environmental hazards posed by the chemical vapors in the tank farms. Together, the four expert declarations establish certain facts and opinions regarding the imminent and substantial endangerment to human health that currently exists at the Hanford site.

A. Statements of Fact

6. I have reviewed a number of reports and documents addressing the tank farms located at the Hanford site's 200 Area, the chemicals located in the tanks at those farms, and reported worker exposures to tank farm chemical

vapors. Reports and documents I have reviewed include those identified in the attached Appendix.

7. From my review of the above-noted documents, I have learned the following facts concerning the underground storage tanks at the 200 Area at the Hanford site.

8. The 200 Area has 18 tank farms that contain 177 underground storage tanks of which 149 are single-shell tanks (SSTs) and 28 are double-shell tanks (DSTs). There are seven tank farms in the 200-West Area and 11 tank farms in the 200-East Area. The tanks in these farms contain waste commonly referred to as being of three types: highly radioactive sludge, lower level radioactive supernatant, and saltcake. The sludge contains high concentrations of both radionuclides and chemicals (both organic and inorganic). Used solvent and complexing agents from separation processes have been discharged to the tanks over time. Ongoing chemical and radiolytic reactions have caused chemical degradation over time, generating compounds that may not have been present in the original waste profiles.

9. Chemical vapors originate from the waste material in the Hanford waste tanks and are released from the tanks to ambient air as chemical vapor emissions from waste tank vents, stacks, alternative tank leakage pathways, and

overflow and transfer lines. Tank headspace composition determines the vapor composition at the point of release for waste tank vapor emissions (e.g., the vent, stack, fugitive emissions). Chemicals confirmed to be present in tank head space include toxic chemicals, both carcinogens and non-carcinogens, with documented adverse human health impacts including chronic effects (i.e., health effects that result from long-term exposure to a chemical) and acute effects (i.e., health effects that result from short-term exposure to a chemical).

10. DOE and its contractors, past and present, have collected numerous samples with the intent of characterizing source vapor chemical concentrations in the waste tanks. Those source vapor samples have been collected for different purposes (e.g., consideration of worker breathing zone exposures, characterization for air permit application or compliance purposes, and evaluation of flammable or explosive conditions). Those source vapor samples have also been collected from a variety of locations (e.g., within the tank headspace, within the exhaust stack near the point of discharge, and outside the exhaust stack near the point of discharge) using a variety of inconsistent sample collection methods. Although the fragmented nature of reporting the source vapor sampling results makes it difficult to understand precisely what source vapor concentrations DOE and WRPS have used as a

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

basis for assessing potential exposures to chemical vapor concentrations in worker breathing zones, DOE and WRPS have attempted to document maximum detected headspace vapor concentrations for some chemicals of potential concern (COPCs) (Stock & Huckaby 2004; Meacham, *et al*. May 2006; Anderson, *et al*. 2006; Hughey & Farler 2008). In the absence of an organized, up-to-date compilation of headspace vapor concentrations, I have compiled the maximum headspace vapor concentrations from those references for a subset of COPCs under consideration in a declaration by Dr. Joyce Tsuji, in a table included as Exhibit 1 to my declaration. Exhibit 1 contains some additional headspace vapor data that I discovered in other reports prepared by DOE, WRPS, or their contractors after the preparation of the above-referenced documents with maximum concentration data. Because the collection and/or reporting of additional headspace vapor data has been limited since preparation of the referenced summary reports, we expect that the maximum concentrations shown in Exhibit 1 may, in fact, underreport actual conditions.

11. Chemical vapors are released from the waste tanks through active or passive ventilation mechanisms. Vapors are emitted from tanks through the risers when they are open to the atmosphere. The SSTs at Hanford have generally been designed and operated to vent passively to the atmosphere

through high-efficiency particulate air (HEPA) filters. SSTs are actively ventilated when waste is being transferred from an SST to a DST. The DSTs at Hanford are generally equipped with active ventilation systems that generate a chemical vapor stream transported to and released from an elevated exhaust stack. Vapors can also escape as fugitive emissions from both SSTs and DSTs through leaking valves, tank covers, and other release points.

12. Waste-disturbing activities (e.g., waste retrieval activities-the pumping of waste from one tank to another tank, or the sluicing of waste in the tanks so that the waste can be pumped out) can greatly alter the concentration and composition of the headspace gases and vapors. Chemical concentrations in headspace vapors have increased significantly during waste-disturbing activities. In studies evaluating the effect of waste-disturbing activities on chemical concentrations in headspace vapors, transient peak concentrations were found to increase as much as three orders of magnitude (i.e., a factor of 1,000 or more, but less than 10,000) (Savannah River National Laboratory (SRNL) 2014).

13. Chemical vapors released from the waste tanks are known to present health and safety risks to Hanford workers. DOE, WRPS, and/or third parties under contract to DOE or WRPS have conducted atmospheric dispersion

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

modeling to estimate a distance proximate to chemical vapor release points at which chemical vapor concentrations are deemed to be safe for unprotected worker exposure. The "vapor control zone," or VCZ, is defined as the area between the vapor release point and the modeled distance to concentrations DOE and WRPS consider protective of worker safety and health. The VCZ is the area in which DOE and WRPS require workers to use respiratory protection equipment.

14. In spite of measures taken to protect workers while they are working in the VCZ, workers have continued to report chemical exposures when working in areas beyond the established VCZs. In some cases, reported chemical exposures have occurred in areas tens or hundreds of feet distant from tanks in which waste-disturbing activities were occurring at the time of exposure. In summary, the VCZs that have been established by DOE and WRPS to protect worker health and safety have, in fact, failed to protect workers from exposure to chemical vapors in the breathing zone.

B. Opinions Regarding Failure to Adequately Characterize Source Vapors

15. The following opinions relate to efforts conducted by DOE and/or WRPS to characterize source vapor concentrations (e.g., in the headspace of

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

tanks) to subsequently support of evaluations of vapor concentrations to which workers could be exposed. These opinions are based on my understanding of source vapor characterization efforts conducted by DOE and/or WRPS, and they are based on my experience characterizing source concentrations associated with chemical releases.

16. Any effort to characterize potential "exposure concentrations" (i.e., a chemical concentration to which a human receptor may be exposed) must be predicated on a known or assumed "source concentration" (i.e., the chemical concentration at or near the chemical's point of origin-or at the point of its release-in the exposure medium of interest). In the Hanford tank vapor matter, estimated or modeled exposure concentrations in worker breathing zones have been based on source concentrations of vapors within the headspace of the waste tanks. I have reviewed documentation regarding four tank vapor exposure assessments performed by DOE and/or WRPS, and the source concentrations used in those assessments are based on the following data: (i) generic unit concentrations, which allow for downwind "fractional concentration" ratios to be applied to maximum source concentrations to estimate the modeled downwind concentrations (Droppo 2004); (ii) "highest source concentrations" from the Site Wide Industrial Hygiene Database

(SWIHD), which appears to be only a partial data set relative to source vapor concentration data collected at the Hanford site, apparently with consideration of only one concentration collected during a waste-disturbing activity (WRPS 2014); (iii) the SWIHD, but solely for tanks in AX-Farm (Schmoldt & Stone 2015); and (iv) annual average emissions from the 2014 air emissions inventory (Joslyn, *et al*. 2016). The source concentrations used as a basis for assessing worker exposure may be representative of quiescent source conditions (with one of the assessments considering a sample at least partially influenced by a waste-disturbing activity), but they are not representative of peak transient concentrations in the headspace source vapor during waste-disturbing activities-and, therefore, the source concentrations that were used in those assessments are not suitable for use in a modeling exercise intended to identify a VCZ protective of workers based on vapor concentrations in the worker breathing zone during waste-disturbing activities. In short, in their modeling exercises to develop appropriate VCZs for worker safety, DOE and/or WRPS have underestimated the source concentrations in tank headspace vapors by up to three orders of magnitude (a factor of 1,000) for conditions contributing to acute (i.e., short-term-less than a day) or bolus (i.e., elevated single-event) exposures.

17. Sampling methods used to characterize headspace vapor concentrations introduce uncertainties and errors leading to underestimation of actual concentrations. The following declarations identify mechanisms by which concentrations may be underestimated by the two most prevalent headspace vapor sampling methods at Hanford: Vapor Sampling System (VSS) and In Situ Sampling (ISS).

18. Bolus releases of elevated chemical vapor concentrations within the tank headspace environment occur not only during waste-disturbing activities initiated by mechanical means or by the addition of materials to the tank from an external environment (both of which may be controlled to avoid influencing sampling results), but also as a result of ongoing chemical reactions in the tank. Buoyant displacement gas release events (BDGREs) periodically release elevated chemical vapor concentrations into the headspace over a short period of time. Due to the sampling time of the VSS and ISS sampling methods (spanning several minutes), short-term peak concentrations released within the headspace environment are diluted by other lower-concentration vapors that constitute the balance of the sample volume.

19. Vapor sampling methods that rely on the active transfer of vapor volumes through or into a sample collection device-as is the case for both VSS

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

and ISS sampling-have the potential to draw unrepresentative gases from interconnected environments into the sample. In the case of headspace vapor sample collection, where the intended sample contains the most elevated chemical concentrations relative to the other interconnected gaseous environment (ambient air), the introduction of any other gas-whether by drawing dilution air into the tank through open tank orifices, or by drawing ambient air into the sampling system through unsealed parts of the sampling train-will serve solely to dilute the sample (i.e., it will never overestimate the concentration and may significantly underestimate the concentration).

20. With respect to the characterization of source vapor concentrations that are representative of conditions leading to reasonable worst-case peak short-term worker exposures, DOE and WRPS have failed to adequately characterize those concentrations for use in evaluating exposure concentrations in worker breathing zones.

C. Opinions Regarding Failure to Adequately Assess Potential Short-Term Exposure Concentrations in Worker Breathing Zones

21. The following opinions relate to the applicability or appropriateness of air quality modeling efforts conducted by DOE and/or WRPS to predict downwind chemical concentrations in worker breathing zones.

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

These opinions are based on my understanding of air quality modeling efforts conducted by DOE and/or WRPS, and they are based on my experience characterizing air quality impacts associated with chemical releases.

22. Several models have been used by DOE and/or WRPS to evaluate the potential for worker exposure to tank vapors and to establish VCZs protective of worker health and safety. Generally speaking, those models fall into one of three categories: atmospheric dispersion models, computational fluid dynamic models, and industrial hygiene mathematical models. Each of the models used by DOE and/or WRPS has fundamental shortcomings in its ability to accurately and reliably predict exposure concentrations in worker breathing zones from source concentrations in tank headspace vapors.

23. Atmospheric dispersion models are used to predict downwind concentrations of a gas-phase chemical based on atmospheric conditions and the characteristics of the chemical release. These models have several fundamental assumptions and operational constraints that limit their ability to accurately and reliably estimate concentrations in worker breathing zones for bolus and acute exposures from tank vapor releases at the Hanford site.

24. Atmospheric dispersion models evaluate steady-state releases under steady-state atmospheric conditions. Although actively ventilated tanks

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

without any waste-disturbing operations might reasonably be characterized as steady-state releases for modeling purposes, there are many tank conditions that cannot be characterized as steady-state releases: rapidly changing conditions reflected during waste-disturbing activities, cyclic vapor releases produced by the "burping" of vapors that accumulate-and release-over periods of time as chemical reactions occur in waste media (e.g., BDGREs), and irregular releases associated with fugitive emissions in passively ventilated tanks (e.g., venting associated with fluctuations in atmospheric temperature and pressure). Atmospheric dispersion modeling is inaccurate and unreliable for estimating air quality impacts associated with non-steady-state chemical releases, which is the condition that exists with the Hanford tank vapor emissions.

25. Atmospheric dispersion models are designed for chemical dispersion beyond 100 meters and up to 50 kilometers from the release location. Dispersion coefficients for short-range receptors have not been appropriately developed for use in commercial atmospheric dispersion models. Simplified mixing models are applied for short-range dispersion, which increases the uncertainty of the results for near-field applications such as the evaluations performed for the Hanford tank vapor releases.

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

26. Atmospheric dispersion models produce time-averaged concentrations within the plume boundary premised on the assumption that concentrations are highest at the center of the plume (using a Gaussian distribution profile). In reality, the plume direction fluctuates and the location of the instantaneous maximum concentration moves around the wider average plume boundary. The variance of the time-weighted average (i.e., the uncertainty associated with the models' accuracy and reliability) is more pronounced at shorter averaging times and shorter distances of evaluation. The minimum averaging time appropriate for the time-averaged result is between 15 minutes and one hour. One means of extrapolating shorter-term concentrations from the minimum time-weighted average concentrations is to apply a peak-to-mean adjustment factor to the result of the dispersion model to estimate peak concentrations. Peak-to-mean adjustment factors attempt to correlate time-weighted average concentrations to shorter peak concentrations that may last from a few seconds to a few minutes. The application of such peak-to-mean adjustment factors introduces substantial uncertainty to atmospheric dispersion modeling results because the data from which they are drawn (1) are not chemical-specific, so they do not take into consideration chemical-specific fate and transport effects, and (2) are not scenario-specific, so they do not take into

consideration the effects of a representative range of local atmospheric and topographic conditions.

27. Atmospheric dispersion models are not equipped to evaluate air quality impacts under calm conditions when wind speeds are at or near zero. Because wind speeds are negligible during calm conditions, which minimizes or eliminates advective dispersion effects (i.e., those effects associated with the movement of air), these are the very atmospheric conditions under which bolus or acute short-term exposures produce the greatest impact to air quality in worker breathing zones. This inability to accurately assess air quality impacts associated with a chemical release under calm atmospheric conditions introduces a greater level of uncertainty for estimates of near-field air quality impacts.

28. Computational fluid dynamics (CFD) models use algorithms for fluid flow and transport within a defined physical boundary. In a comparison between an atmospheric dispersion model and a CFD model, for the purposes of evaluating downwind tank vapor concentrations at the Hanford site, Joslyn, *et al*. (2016), concluded that the atmospheric dispersion model "proved to be more capable at handling specific atmospheric phenomena" than the CFD model. (Joslyn, *et al*. 2016, p. ES-1). CFD models were not recommended for

continued use in estimating air quality impacts associated with tank vapor releases at the Hanford site.

29. The American Industrial Hygiene Association (AIHA) has published several mathematical models for estimating worker exposure to chemical vapor releases (AIHA 2009). Versions of these AIHA models have been used to recommend distances for VCZs at Hanford tank farms.

30. The AIHA mathematical dispersion model is based on the same steady-state Gaussian dispersion equations described in paragraph 26 above, and are limited by the same constraints of the Gaussian model assumptions. Estimated air quality impacts generated by the AIHA models are time-averaged concentrations, not instantaneous peak concentrations.

31. The dispersion elements of the Gaussian equations have been simplified in the AIHA mathematical models. The AIHA mathematical models have not been adequately validated for use in complex atmospheric conditions.

32. I have reviewed four air quality modeling evaluations performed by DOE, WRPS, and/or their contractors. An objective of two of the four evaluations was to establish VCZs protective of worker health and safety (WRPS 2014; Schmoldt & Stone 2015). A third evaluation used generic unit concentrations for source vapors (Droppo 2004), which would conceptually

allow DOE and WRPS to apply maximum headspace vapor concentrations when evaluating VCZs appropriate for specific COPCs. In addition to the general limitations and inadequacies identified above for the models DOE and/or WRPS have used to evaluate air quality impacts in worker breathing zones, I note the following concerns with (or arising from) the specific application of models in the evaluations performed by Droppo, WRPS, Schmoldt and Stone, and Joslyn, *et al*.

33. The Droppo evaluation makes use of atmospheric dispersion modeling based on the Industrial Source Complex (ISC) algorithms developed by the U.S. Environmental Protection Agency. For the purposes of establishing VCZs around tank vapor release points at the Hanford site, the Droppo evaluation is constrained by the shortcomings and limitations described for atmospheric dispersion models in paragraphs 23 through 27 above.

34. Certain elements of the atmospheric dispersion modeling used to support the Droppo evaluation are not documented with sufficient detail to assess whether the modeling characterizes reasonable worst-case conditions. Due to uncertainty around the simplified atmospheric parameterization, lack of validation of the release parameters, unconfirmed peak-to-mean adjustment, and unknown influence of surface roughness, terrain, and building downwash, it

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

is unclear whether the modeled results represent the worst-case concentration estimate.

35. Droppo states, "During routine emissions, the concentrations in the tank headspaces are assumed to represent the maximum concentrations that will be released and can potentially occur in the environment." (Droppo 2004, p. 4). This statement fails to acknowledge the implications of exposures during periods of non-routine emissions, namely, the magnitude of exposures that may occur when waste-disturbing activities increase concentrations in tank headspace vapor by as much as three orders of magnitude.

36. Droppo correctly observes that "The issue of concentration variability and especially short-duration peaks needs to be addressed to better understand the potential for worker exposures to occasionally higher concentrations. That is, the computed average worker exposures may well be within acceptable exposure limits-but a worker may smell or otherwise react to higher short-term peak concentrations." (Droppo 2004, p. 6). In the context of frequent, ongoing reports of worker exposures to breathing-zone chemical vapors (HPM Corporation (HPMC) 2016), and medical care for related symptoms, DOE and WRPS have failed to appropriately act on Droppo's admonition to better understand the potential for workers to be exposed to

higher short-term peak concentrations than those estimated by dispersion models-and in failing to adequately understand the potential for higher short-term peak concentrations, DOE and WRPS have failed to adequately protect workers from reportable vapor exposures.

37. Both qualitatively and quantitatively, Droppo describes concerns about breathing-zone vapor concentrations at distances far greater than any VCZ ever established by DOE or WRPS. Qualitatively, Droppo defines "near-field instantaneous concentrations" as "rapid concentration fluctuations . . . approaching undiluted concentrations" (Droppo 2004, p. 1)-and he further states that the distances at which these near-field, nearly-undiluted concentrations "may be very close to a venting location-*or at some close distance including locations in adjacent tank farms*" (*Id*., p. 3) (emphasis added). The potential concern about breathing-zone vapor concentrations is reinforced by Droppo's quantitative modeling results. For vapor release scenarios with low vapor release velocities from the stack and low wind speeds, Droppo models downwind concentrations that remain at significant levels at several extended distances from the original vapor release: up to 60 percent of the source concentration at 30 meters downwind, up to 12 percent at 100 meters, up to 1.6 percent at 300 meters, and up to 0.18 percent at 1,000 meters (*Id*., Tbl. A.2). In

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

other words, Droppo's modeling indicates that for a chemical such as N-nitrosodimethylamine (NDMA), with source vapor concentrations up to 360 parts per million by volume (ppmv; the maximum concentration detected in headspace vapors (Ex. 1) times a factor of up to 1,000 to account for short-term peak concentrations associated with waste-disturbing activities), concentrations exceeding the Level 2 protective action criteria (PAC-2, at which irreversible or serious health effects could impair a worker's ability to take protective action) of 0.3 ppmv (Declaration of Joyce Tsuji (Tsjui Decl.)) could persist at downwind distances of more than 1,000 meters (more than 3,300 feet) from the vapor release. Chemicals such as ammonia, which can be detected by smell, have a similar or greater potential for concentrations of concern at downwind distances exceeding 300 meters. The conclusions that can be drawn from Droppo's modeling and maximum anticipated source vapor concentrations (Ex. 1; SRNL 2014) may be further supported by reported tank vapor exposures occurring hundreds of feet away from releases associated with waste-disturbing activities in AP-Farm in April and May 2016 (HPMC 2016). In spite of its modeling limitations, the evaluation performed by Droppo and the maximum anticipated source vapor concentrations during waste-disturbing activities-which can be 1,000 times the source vapor concentrations detected in

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

tank headspace prior to waste-disturbing activities (SRNL 2014)-provided DOE and WRPS ample information to understand that tank vapors could persist at concentrations of concern for worker health and safety at distances up to and greater than 3,300 feet. During my visit to the Hanford site on June 23, 2016, I observed VCZs of merely five feet from tank vents. The information summarized above was obtained from data readily available to DOE and WRPS; it was prepared by contractors they have retained for the explicit purpose of understanding potential concerns about worker health and safety issues stemming from chemical exposures in tank vapor release events. DOE and WRPS have failed to appropriately respond to the potential for chemical vapor exposure in worker breathing zones hundreds of feet from vapor release points.

38. The presentation titled *Evaluation of Air-Purifying Respiratory Protection Requirements for Tank Farms* (WRPS 2014) summarizes the results of AIHA air dispersion modeling intended to identify the distance at which chemical concentrations declined to a level that WRPS would use to establish respiratory protection requirements. For the purposes of establishing VCZs around tank vapor release points at the Hanford site, the WRPS evaluation is

constrained by the shortcomings and limitations described for AIHA models in paragraphs 29 through 31 above.

39. The WRPS presentation states that the AIHA model is a "validated empirical model, not a simple dispersion calculation." (WRPS 2014, p. 4). Both of WRPS's claims in that statement contradict information presented in the reference document for the model itself (AIHA 2009). The AIHA model reference repeatedly calls out model validation as an important element of refining the accuracy and usefulness of industrial hygiene models and describes the extent to which validation has been performed for many of the models described in the reference. Shortcomings in the extent of validation of the AIHA air dispersion model are explicitly mentioned in the reference document: "The near field and mid field plume models presented below have had limited validation, and their results are an estimate that may or may not compare well to either more recent and more parameter intensive models or measurements." (AIHA 2009, p. 153). AIHA note a wide range of conditions and parameters that are included in "fully developed Gaussian plume models," and then acknowledge that when developing the AIHA model for industrial hygiene applications, "we will restrict ourselves to the more simple neutral buoyancy and non-reactive systems" (*Id*., p. 154). With respect to both model validation

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

and the extent of simplifying conditions, the WRPS (2014) claims directly contradict the assessments made by AIHA in its description of the model's shortcomings.

40. The AIHA model generally considered source vapor concentrations representative of quiescent tank conditions. One concentration-that of NDMA in a C-Farm exhauster stack-was from a sample collected "during C-Farm waste disturbing activities" (WRPS 2014, p. 7); even that concentration is unlikely to represent peak concentrations during the waste-disturbing activities performed at that time (SRNL 2014; ¶ 16, *supra*).

41. In spite of the shortcomings associated with the AIHA model, it still produced results indicating distances of potential concern that DOE and WRPS failed to adequately consider in their development of worker protection procedures. Dispersion modeling results indicate chemical concentrations of concern to a distance of 28.9 feet (suggesting an accuracy of model prediction that is not warranted by the limitations of the model for this purpose) for NDMA during waste-disturbing activities. Although WRPS recommended that "[a]ny waste disturbing activity performed in C-Farm should result in an establishment of the entire farm as a VCZ" (WRPS 2014, p. 12), it failed to recognize and act on the fact that waste-disturbing activities in any tank farm

will produce elevated source concentrations that should trigger the requirement for an expanded VCZ.

42. The Schmoldt and Stone evaluation used an eddy diffusion model prepared by AIHA for use in indoor industrial hygiene applications (AIHA 2009). Schmidt and Stone used the model to consider chemical vapor migration from AX-Farm tanks during non-waste disturbing activities. The model provides for an evaluation of eddy diffusion with advective forces (i.e., causing a reduction in concentration by active movement of the air, for example, by wind) following a pulse vapor release. The model, which is highly dependent on the "turbulent eddy diffusion coefficient" has not been validated for use in characterizing downwind chemical concentrations when complex atmospheric conditions or terrain may influence chemical vapor migration.

43. Schmoldt and Stone's presentation of the modeling performed is erroneous and misleading. Their text states, "the Model author recommended the *utilized* 0.1 meter/minute wind speed as a worst case scenario" for atmospheric dispersion effects (Schmoldt & Stone 2015, p. 4) (emphasis added). Table 2 of the Schmoldt and Stone report presents a modeling summary claiming a "0.1 meters per minute wind speed" (*Id.*, p. 8). The modeled distances proclaimed as protective for ammonia, however, are actually

based on a wind speed of 1.524 meters per minute (*Id*., Attachs. 1, 2)-more than 15 times the wind speed recommended by the model author for a worst-case scenario. Raising additional concern is the inconsistency between modeling results in the report attachments for 2,3-dihydrofuran and NDMA.

44. The Joslyn, *et al*. evaluation of two air models was not explicitly performed to support the development of VCZs; however, the results do call attention to a shortcoming in dispersion modeling that has yet to be adequately assessed relative to the tank vapor exposure matter at Hanford: workers may, in fact, be exposed to elevated short-term chemical vapor concentrations that exceed those predicted by models (*see also* ¶ 36, *supra*). In the case of the Joslyn, *et al*. evaluation, the modeling leads WRPS to conclude that "Ammonia also had a peak concentration of 0.03 ppm, slightly below its reported odor threshold of 0.04 ppm. Evaluation of the correlation of 1-hr averaged results to shorter time periods suggests that the ammonia from stack emissions may rarely exceed its odor threshold" (Joslyn, *et al*. 2016, p. ES-2). This conclusion, which is based on WRPS's modeling that is intended to be conservative, is not supported by the frequent and pervasive occurrence of worker complaints related to the inhalation of chemical vapors bearing a recognizable ammonia odor.

45. With respect to the use models to estimate exposure concentrations in worker breathing zones, I conclude that (1) each of the models that DOE and WRPS has used-and that I have reviewed-has substantive limitations and shortcomings that negatively affect its ability to accurately and reliably estimate maximum expected peak short-term concentrations in the breathing zone, and (2) when presented with modeling and source vapor concentration data that would indicate concentrations of concern for worker health and safety at distances ranging from tens to hundreds of feet from release points, DOE and WRPS repeatedly failed to adequately respond to those data by instituting engineering controls or expanding VCZs to reflect the broader areas of potential concern.

D. Opinions Regarding Failure to Identify Protective Vapor Control Zones

46. When empirical data (i.e., data that is obtained by observation, in contrast to estimates that are made by modeling) is available, it is common practice to use that empirical data as a frame of reference to calibrate a model so that its future use may be more accurate and reliable for its intended purpose. Model calibration is especially important when, as identified above, the model has limitations that reduce its accuracy and reliability for the objective the

model is intended to achieve. It is impracticable to collect empirical data in the form of worker breathing zone chemical concentrations characterizing reasonable worst-case conditions for a bolus or acute short-term exposure associated with tank vapor releases. However, the ultimate objective of the air quality modeling performed by DOE and/or WRPS-at least as it relates to the matter considered by the subject motion for preliminary injunction-is to identify areas in which measures should be taken to protect worker health and safety (i.e., VCZs). Under federal regulations, WRPS is required to "provide a place of employment that is free from recognized hazards that are causing or have the potential to cause death or serious harm to workers" (Declaration of Bruce Miller, ¶ 11). Dr. Tsuji has concluded that "tank exposures cause health effects and pose risks of serious, irreversible impairment," and "a subset of these health effects are not immediately reversible and some workers have experienced permanent damage to their health." (Tsjui Decl. ¶¶ 12.d; 12.d.2). With that context, reported vapor exposures-in the form of complaints of odors accompanied by health symptoms consistent with acute exposure to COPCs in tank vapors-are just as valid as detections of peak short-term concentrations (which are impracticable to obtain through available sampling methods) as data points that establish a relationship between (1) distance from tank vapor release points, especially during waste-disturbing activities, and (2) chemical vapor concentrations in worker breathing zones that create conditions that are not protective of worker health and safety. Based on the unreliable performance of air quality models employed by DOE and WRPS-with results supporting recommendations of VCZs ranging from less than 10 to greater than 3,300 feet-the benefits associated with calibrating one or more of the models would be small: the nuances of atmospheric conditions, time-specific source concentrations, and other scenario-specific conditions make refined modeling efforts futile for a worker protection scenario such as the Hanford tank vapor exposure matter. Instead, those models should be relegated to the purpose of informing preliminary worker safety plans prior to the occurrence of documented worker exposures. That time has passed. Following the occurrence of documented worker exposures, the use of empirical data (worker complaints of odors accompanied by health symptoms consistent with acute exposure to chemicals of potential concern in tank vapors) is the most reliably protective way to establish areas in which DOE and WRPS should take measures to protect workers from tank vapor exposures.

47. I conclude that DOE and WRPS have failed to adequately incorporate worker complaints of odors accompanied by health symptoms

consistent with acute exposure to COPCs in tank vapors in establishing work areas in which respiratory protection is required of workers.

DATED this 14th day of July 2016, in Seattle, Washington.

Charles Halbert

CHARLES HALBERT

APPENDIX

1. American Industrial Hygiene Association, *Mathematical Models for Estimating Occupational Exposure to Chemicals*, AIHA 2nd ed. (Jan. 4, 2009)

2. Anderson, T.J., M.L. Zabel, N.K. Butler, *A-Prefix Tank Farms Vapor Hazard Characterization Report*, RPP-RTP-29262, Rev. 0 (PNNL-016623), prepared for the U.S. Dep't of Energy, Office of River Protection, by CH2MHILL Hanford Group, Inc. (April 2006)

3. Droppo, J.G., *Characterization of the Near-Field Transport and Dispersion of Vapors Released from the Headspaces of Hanford Site Underground Storage Tanks*, PNNL-14767, prepared for the U.S. Dep't of Energy by Pacific Northwest National Laboratory (July 2004)

4. Gent, P., telephone interview *Re: Hanford Tank Farm Vapors* with J. Level and T. Young (Washington State Office of the Attorney General); B. Cox, S. Dee and R. Ogle (Exponent, Inc.); J. Wilson (Wilson Technical Services); and C. Halbert (Landau Associates, Inc.) (May 25, 2016)

5. HPM Corporation, *Odor related medically evaluated employee, April 1 through June 1, 2016* (June 7, 2016)

6. Hughey, M.T. and D.F. Farler, *C Tank Farm Vapor Hazard Characterization Report*, RPP-RPT-35018, Rev. 0 (PNNL-018441), prepared for the U.S. Dep't of Energy, Office of River Protection, by CH2MHILL Hanford Group, Inc. (Jan. 2008)

7. Joslyn, C.C., T. Messier, C. Stebbings, *Atmospheric Dispersion Modeling of 200 East Area Tank Farm Stacks*, RPP-RPT-58955, Rev. 00, prepared for the U.S. Dep't of Energy, Office of River Protection, by Washington River Protection Solutions, LLC (Jan. 2016)

8. Meacham, J.E., J.O. Honeyman, T.J. Anderson, J.L. Huckaby, *Industrial Hygiene Chemical Vapor Technical Basis*, RPP-RPT-22491, Rev. 1, prepared for the U.S. Dep't of Energy, Office of River Protection, by CH2MHILL Hanford Group, Inc. (May 2006)

9. Meacham, J.E., L.A. Mahoney, and J.A. Huckaby, *Concentrations of chemicals of potential concern in water and organic condensates*, RPP-

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

RPT-24794, Rev. 1, prepared for the U.S. Dep't of Energy, Assistant Secretary for Environmental Management, by CH2M HILL Hanford Group, Inc. and Pacific Northwest National Laboratory (Mar. 2006)

10. Declaration of Bruce Miller in Support of Plaintiff State of Washington's Motion for Preliminary Injunction, *Hanford Challenge v. Moniz*, No. 4:15-cv-05086-TOR (E.D. Wash. July 20, 2016)

11. Schmoldt, M.J. and R.C. Stone, *Respiratory Protection Protocol & Methodology Technical Evaluation – AX Farm*, RPP-RPT-58826, Rev. 00, prepared for the U.S. Dep't of Energy, Office of River Protection, by Washington River Protection Solutions, LLC (July 2015)

12. Savannah River National Laboratory, *Hanford Tank Vapor Assessment Report*, SRNL-RP-2014-000791 (Oct. 30, 2014)

13. Stewart, C.W., M.S. Fountain, J.L. Huckaby, L.A. Mahoney, P.A. Meyer, B.E. Wells, *Effects of Globally Waste-Disturbing Activities on Gas Generation, Retention, and Release in Hanford Waste Tanks*, PNNL-13781, Rev. 3, prepared for the U.S. Dep't of Energy by Pacific Northwest National Laboratory (July 2005)

14. Stock, L.M. and J.L. Huckaby, *A Survey of Vapors in the Headspaces of Single-Shell Waste Tanks*, PNNL-13366, Rev. 1, prepared for the U.S. Dep't of Energy by Pacific Northwest National Laboratory (July 2004)

15. Site Wide Industrial Hygiene Database Systems, data report *Re: AN Exhauster Air Sampling for Mercury from 06/01/2012 to present* (date unknown)

16. Declaration of Joyce Tsuji in Support of Plaintiff State of Washington's Motion for Preliminary Injunction, *Hanford Challenge v. Moniz*, No. 4:15-cv-05086-TOR (E.D. Wash. July 20, 2016)

17. Washington River Protection Solutions, LLC, *Evaluation of Air-Purifying Respiratory Protection Requirements for Tank Farms* (presentation) (Dec. 8, 2014)

18. Environmental Operational Activities Notification from D. Dyekman (Washington River Protection Solutions, LLC) to P. Gent (Washington State Dep't of Ecology) *Re: Analytical Results Submitted to Ecology for 241-AY/AZ Ventilation System Stack Samples* (Apr. 13, 2016)

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770

PROOF OF SERVICE

I certify that I electronically filed the foregoing document and accompanying exhibit with the Clerk of the U.S. District Court using the CM/ECF system which will send notification of such filing to all parties of record as follows:

- **Thomas J. Young**
  tomy@atg.wa.gov, ecyolyef@atg.wa.gov
- **John A. Level**
  johnl3@atg.wa.gov, ecyolyef@atg.wa.gov, teresat@atg.wa.gov
- **Kelly T. Wood**
  kellyw1@atg.wa.gov, deborah.holden@atg.wa.gov, ecyolyef@atg.wa.gov
- **William R. Sherman**
  bills5@atg.wa.gov
- **Meredith A. Crafton**
  meredithc@igc.org
- **Richard A. Smith**
  rasmithwa@igc.org
- **Richard Webster**
  rwebster@publicjustice.net
- **Beth E. Terrell**
  bterrell@terrellmarshall.com
- **Blythe H. Chandler**
  bchandler@terrellmarshall.com
- **Sheila Baynes**
  sheila.baynes@usdoj.gov, EFILE_EDS.ENRD@USDOJ.GOV

- **Elizabeth B. Dawson**
  elizabeth.dawson@usdoj.gov, EFILE_EDS.ENRD@usdoj.gov
- **Austin David Saylor**
  austin.saylor@usdoj.gov, efile_eds.enrd@usdoj.gov
- **Vanessa Ruth Waldref**
  USAWAE.VWaldrefECF@usdoj.gov, mary.f.buhl@usdoj.gov, Vanessa.R.Waldref@usdoj.gov
- **J. Chad Mitchell**
  chadm@summitlaw.com, kristeno@summitlaw.com, deniseb@summitlaw.com
- **David M. Heineck**
  davidh@summitlaw.com, laureel@summitlaw.com
- **Sara A. Kelly**
  sarak@summitlaw.com

In addition, the following individuals have received the foregoing document via e-mail, pursuant to the parties' e-service agreement:

- **Steve Cherry**
  stephen_b_cherry@rl.gov
- **Nada Barnes**
  nada_barnes@rl.gov
- **Mark Nitczynski**
  mark.nitczynski@usdoj.gov
- **Mark Silberstein**
  mark.silberstein@rl.doe.gov
- **Ann Duer**
  ann.duer@usdoj.gov

- **Jennifer Boschen**
  jboschen@terrellmarshall.com
- **Molly Jones**
  mollyj@summitlaw.com

DATED this 21st day of July 2016.

s/ Thomas J. Young
THOMAS J. YOUNG

ATTORNEY GENERAL OF WASHINGTON
PO Box 40117
Olympia, WA 98504-0117
(360) 586-6770