

**UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION**

Before the Atomic Safety and Licensing Board

In The Matter Of:

FLORIDA POWER & LIGHT COMPANY

(Turkey Point Units 6 and 7)

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**Docket Nos. 52-040-COL & 52-041-COL
ASLBP No. 10-903-02-COL-BD01**

PRE-FILED DIRECT TESTIMONY OF DR. CHRISTOPHER M. TEAF

Introduction

Please state your name and business address.

1. My name is Dr. Christopher M. Teaf. My business address is 2976 Wellington Circle West, Tallahassee, FL.

Please describe your professional credentials and experience.

2. I earned a Bachelor's degree in Biology (with Honors) from Pennsylvania State University (1975), a Master's degree in Biological Science from Florida State University (1980), and a Ph.D. in Toxicology from the University of Arkansas for Medical Sciences (1985). I conducted my research in the Division of Genetic Toxicology at the National Center for Toxicological Research in Jefferson, Arkansas. My Curriculum Vitae is included as Attachment A to this Testimony.
3. Since 1985, I have held the position of Director of Toxicology for Hazardous Substance & Waste Management Research, Inc. (President since 1989), and also have served on the Florida State University (FSU) faculty since 1979. I have served as Director and Associate Director of the Center for Biomedical & Toxicological Research at FSU. In addition to those positions, I have held adjunct teaching and/or research appointments at the University of Arkansas for Medical Sciences, the FSU College of Medicine, the State University

System Program in Medical Sciences (Florida), and the Environmental Toxicology program in the Florida A&M University College of Pharmacy & Pharmaceutical Sciences.

4. I am Board-certified as a Fellow of the Academy of Toxicological Sciences, an international professional organization.
5. My research and scientific advisory activities principally have been in the areas of health risk assessment, hazardous materials management, and toxicology of environmental and occupational chemicals, as well as biological and physical agents. My professional activities for well over 35 years have included performance of several hundred chemical risk assessments addressing human health, chemicals management, and evaluations of potential for exposure and adverse effects related to chemical exposures. These activities have been conducted according to requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, Superfund), the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Occupational Safety and Health Act (OSHA), and related local, state, or federal regulations. The activities have involved evaluating potential human health impacts from organic and inorganic substances in groundwater, surface water, soils, sediments, and air. The substances include, among others, pesticides, chlorinated and non-chlorinated solvents, petroleum products, metals, acids/caustics, particulates, fibers, and microbial agents (e.g., mold, bacteria).
6. For over 3 decades, I have directed and conducted health research and education projects for the World Health Organization (WHO), North Atlantic Treaty Organization (NATO), U.S. Environmental Protection Agency (USEPA), U.S. Department of Energy (USDOE), U.S. Department of Agriculture (USDA), U.S. Centers for Disease Control and Prevention/Agency for Toxic Substances & Disease Registry (CDC/ATSDR), Florida Department of Environmental Protection (FDEP), Florida Department of Health (FDOH), Florida Department of Community Affairs (FDCA), local governments, and private firms.
7. Throughout my career, I have served as a scientific peer reviewer for publications submitted to technical journals in toxicology and related fields, and I have served on Editorial Boards or as an editor for several scientific journals relating to the health effects of chemical contamination. I have published many scientific papers and book chapters on

subjects in the disciplines of toxicology, exposure assessment, environmental chemical behavior, hazardous materials management, and risk evaluation for environmental and occupational chemicals.

8. As described in my CV, since 1986 I also have served as a toxicologist on various governmental committees and commissions in the State of Florida, including for the FDEP. For example, from 2012 to 2016 I worked on the Human Health Peer Review Committee of the FDEP, addressing the development of health-based criteria for water.
9. Finally, I have provided toxicological and public health advisory services to the U.S. Attorney, Florida State Attorney's Office, and Attorneys General of Florida, Oklahoma, and Washington.

Please explain the purpose of your Testimony.

10. I was retained by Florida Power & Light (FPL) regarding a challenge before the Nuclear Regulatory Commission (NRC) by Mark Oncavage, Dan Kipnis, the Southern Alliance for Clean Energy, and the National Parks Conservation Association (hereafter the Joint Intervenors) to FPL's Combined License (COL) application for two new nuclear power reactor units, Turkey Point Units 6 and 7, to be constructed at FPL's facility near Homestead, Florida.
11. Specifically, in its most recent ruling (Memorandum and Order, 2016), the NRC Atomic Safety and Licensing Board (Board) concluded that there was no genuine issue of material fact regarding the first component of Joint Intervenors' Contention 2.1, namely that the alleged concentrations of four chemicals (i.e., heptachlor, ethylbenzene, toluene, and tetrachloroethylene) in the wastewater proposed by FPL for injection into the Boulder Zone were not accurate or reliable. The Board therefore granted FPL's motion to dismiss that first component of the Contention. However, the Board retained for further consideration the second component of Contention 2.1, which disputed FPL's assertion that it was highly unlikely that wastewater would migrate to and adversely impact the Underground Source of Drinking Water (USDW) in the Upper Floridan Aquifer (UFA). Memorandum and Order, 2016 at p. 14.

12. My Testimony addresses whether wastewater from Turkey Point operations would exert “small,” or even detectable, effects on the USDW. My understanding is that “small” in this context is defined as a situation wherein “[e]nvironmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.” NRC-008A (FEIS) at p. 1-4.

What did you rely upon to form your opinions?

13. In preparing my analysis and developing my professional opinions for this matter, I relied upon greater than three decades of training and experience as a toxicologist and health risk assessor, as well as reviewing and/or relying upon the following documents:
- *Florida Power & Light Company* (Turkey Point, Units 6 and 7), LBP-16-03, N.R.C. Apr. 21, 2016. (Memorandum and Order, 2016).
 - Environmental Impact Statement for Combined Licenses (COLs) for Turkey Point Nuclear Plant Units 6 and 7. Draft Report for Comment. Volume 1. February 2015 (DEIS).
 - Environmental Impact Statement for Combined Licenses (COLs) for Turkey Point Nuclear Plant Units 6 and 7. Final Report (Volume 1 & Volume 2). October 2016 (FEIS) (NRC-008).
 - First Affidavit of Mark A. Quarles, January 23, 2012 (Quarles, 2012a).
 - Second Affidavit of Mark A. Quarles, February 17, 2012 (Quarles, 2012b).
 - Declaration of Mark A. Quarles, August 3, 2012 (Quarles, 2012c).
 - Third Affidavit of Mark A. Quarles, February 2, 2016 (Quarles, 2016c).
 - State of Florida and federal regulations and standards regarding public drinking water supplies.
 - February 3, 2016 NRC Staff Answer to "Florida Power & Light Company's Motion for Summary Disposition of Joint Intervenor's Amended Contention 2.1," Docket Nos. 52-040 & 52-041 (February 2016 Staff Answer).
 - April 5, 2016 Official Transcript of Proceedings, Nuclear Regulatory Commission, Florida Power & Light Company Turkey Point Units 6 and 7, Docket Nos. 52-040 and 52-041 (April 2016 Transcript).

- Various submittals by FPL in this proceeding, and various technical literature references, which are cited in abbreviated form in this Testimony and identified in full in Attachment B to this Testimony.
14. This is the type of information on which I, and others in the fields of toxicology and health risk assessment, typically rely to form our professional opinions.

Summary

Please summarize your opinions.

15. The professional opinions that I hold in this matter, which are described in greater detail in subsequent sections of my Testimony, can be summarized as follows:
- The four chemicals of interest (i.e., heptachlor, ethylbenzene, toluene, tetrachloroethylene), if present in reclaimed wastewater at the concentrations set forth in Table 3-5 of the FEIS, *will have no detectable impact on sources of drinking water or the UFA with regard to human health, even if the wastewater is directly injected into the drinking water or the UFA*, much less if it is injected into the Boulder Zone as proposed by FPL. Accordingly, it is entirely unfounded for Joint Intervenors to contend that the FEIS was deficient because it concluded that the environmental impacts from these chemicals in the Turkey Point wastewater will be "small";
 - Claims by Joint Intervenors that the four chemicals in the concentrations at issue may cause adverse health effects are not supported by the literature, or by my training and over three decades of experience in the disciplines of toxicology and health risk assessment. Any reported effects resulted from concentrations far in excess of those set forth in FEIS Table 3-5;
 - The concentrations for the four chemicals of interest as set forth in FEIS Table 3-5 are all below federal drinking water standards. This means that, with regard to these four chemicals, the injectate would not be harmful to the public health, even if it were injected directly into drinking water or the UFA;
 - Claims by the Joint Intervenors related to the health impacts of the potential breakdown products of heptachlor and tetrachloroethylene are unfounded; and
 - Claims by the Joint Intervenors that the four chemicals in the wastewater are unsafe at even minute concentrations are unfounded.

For these reasons, I concur with the FEIS determination that the environmental impact of injected wastewater from Turkey Point will be "small" (*see* NRC-008 (FEIS) at 5-41, 5-

42), if any. The concentrations of the four chemicals of interest will not adversely affect public health.

How will FPL use reclaimed wastewater?

16. FPL proposes to use reclaimed wastewater obtained from Miami-Dade County's South District Wastewater Treatment Plant (South District Plant) as the primary source of makeup water in the circulating water system that is to be used in the cooling towers for Turkey Point Units 6 and 7. That reclaimed water would receive further treatment at FPL's reclaimed water treatment facility prior to being stored in Turkey Point's makeup water reservoir. From the makeup water reservoir, the water would be directed for use in the cooling towers. The final blowdown material that remains after passage through the cooling towers, as well as other plant discharge effluents, would be collected in a storage sump and subsequently injected into the Boulder Zone within/beneath the Lower Floridan Aquifer system at a projected depth of approximately 3,000 feet below land surface. NRC-008A (FEIS) at 2-55, 2-58, 3-8, 3-9, 3-31, 3-32.

What chemical concentrations are at issue in this proceeding?

17. I understand that the issue in this proceeding is the impact of the concentrations of heptachlor, ethylbenzene, toluene, and tetrachloroethylene, as set forth in Table 3-5 of the FEIS (values reproduced below in Table 1 for ease of reference). It is worth noting, in addition, that subsequent grab and composite water samples from the South District Plant were collected in 2013 and 2014, and those samples were analyzed for the chemicals of interest. None of the four chemicals were detected in any of those 2013 and 2014 water samples at concentrations greater than the analytical Method Detection Limit (MDL)¹ reported for each chemical. *See generally* FPL-041 (FPL, 2013a); FPL-042 (FPL, 2013b); FPL-043 (FPL, 2013c); FPL-044 (FPL, 2013d); FPL-045 (FPL, 2014a); FPL-046 (FPL, 2014b).

¹ MDL is the minimum concentration of a substance that can be measured and reported by the laboratory with 99% confidence that the value is above zero. *See* 40 CFR Ch. I Pt. 136, App. B, July 1, 2002).

Table 1. Chemical Concentrations in Table 3-5 Versus Federal Standards

| Constituent | FEIS Table 3-5 Concentration (mg/L) | USEPA Standard (mg/L) ² |
|---------------------|---|---------------------------------------|
| Heptachlor | 0.000023 | 0.0004 |
| Ethylbenzene | Below MDL ³ | 0.7 |
| Toluene | 0.00174 | 1 |
| Tetrachloroethylene | 0.00359 | 0.005 |

Chemical & Toxicological Properties for Chemicals of Interest

What is heptachlor?

18. Heptachlor is a chlorinated insecticide that, in pure form under ambient conditions, appears as a white or light tan crystalline solid with a mild camphor or cedar-like odor. Heptachlor can be hydrolyzed in water to 1-hydroxychlordehene and heptachlor epoxide. It also can be biodegraded to heptachlor epoxide by bacteria and in animal tissues. Use of heptachlor was phased out beginning in 1974 and the USEPA prohibited the future sale, distribution, shipment, and use of heptachlor in 1988, with the exception of specific application for treatment of fire ants in underground power transformers. The manufacturer of heptachlor did not renew the registration for the chemical in 1999, so it does not appear that there are current uses beyond those that may rely on historical stocks of the material. FPL-038 (ATSDR, 2007c). Although heptachlor has a very low solubility in water and a very low vapor pressure (FPL-038 (ATSDR, 2007c)), volatilization of heptachlor,⁴ while not rapid or efficient, may occur to a very limited extent.

² See FPL-054 (USEPA, 2016a).

³ The measurements for Ethylbenzene were below the method detection limit (MDL), i.e. the concentrations were so small that they could not be measured reliably.

⁴ In this application, volatilization refers to the process by which a substance moves from the dissolved phase in water to the gas phase in air.

Have there been health effects attributed to heptachlor exposure?

19. Certain health impacts have been reported in animals exposed to high doses of heptachlor. FPL-038 (ATSDR 2007c) at 043-066. However, health effects observed at such high doses do not translate into similar, or indeed any, effects at low doses. The lowest exposure level at which adverse effects have been observed (known in the field of toxicology as the “Lowest Observed Adverse Effect Level” or LOAEL) in those animal studies was 0.03 mg/kg•day. FPL-038 (ATSDR, 2007c) at 052. That is more than *49,500 times greater* than the dose that could occur from exposure to heptachlor at the concentration set forth in FEIS Table 3-5, even if that wastewater was directly consumed as a drinking water source.⁵ Stated differently, even at doses 49,500 times greater than those which may be associated with the concentration in FEIS Table 3-5, no effects would be expected in animals or humans.

Have the USEPA and the FDEP established drinking water standards for heptachlor?

20. Yes. The protective drinking water standard (Maximum Contaminant Level or MCL) established by the USEPA for heptachlor is 0.0004 mg/L. FPL-054 (USEPA, 2016a) at 009; *see* Table 1 above. The protective drinking water standard established by the FDEP for heptachlor is also 0.0004 mg/L. FPL-053 (FDEP, 2015) at 055. Concentrations equal to or less than these standards are considered safe for consumption in drinking water. The FEIS Table 3-5 concentration for heptachlor is 0.000023 mg/L, well below the federal and state safe drinking water standards. The USEPA has also developed a Maximum Contaminant Level Goal (MCLG) of zero for heptachlor (and tetrachloroethylene), among numerous other substances. FPL-054 (USEPA, 2016a) at 009, 011. An MCLG is a highly conservative, non-enforceable public health goal that the USEPA recognizes public water systems often cannot meet due to technological limitations. FPL-054 (USEPA, 2016a) at 012-13; FPL-057 (USEPA, 2016b) at 004. Because MCLGs include a large margin of safety, detection of a chemical above the MCLG, but below the MCL, does not indicate a

⁵ I made this calculation using the following formula: Heptachlor Dose Ratio (49,630) = [LOAEL (0.03 mg/kg•day)] / [(0.000023 mg/L x 2 L/day Ingestion Rate) / 76.1 kg Body Weight]. The 2 L/day Ingestion Rate and 76.1 kg Body Weight are values used by federal and state agencies in the calculation of doses and potential risks from drinking water exposures.

human health risk. FPL-054 (USEPA, 2016a) at 001; FPL-057 (USEPA, 2016b) at 004; FPL-058 (USEPA, 2006) at 001; FPL-059 (USEPA, 1992) at 108.

What is ethylbenzene?

21. Ethylbenzene in its pure form is a colorless, flammable liquid with an aromatic odor. FPL-037 (ATSDR, 2010) at 167. It is a natural component of petroleum products and commonly is found in aviation and motor vehicle fuels. *Id.* It also is found as a component of common solvents, pesticides, printing ink, varnishes, coatings, and paints. FPL-037 (ATSDR, 2010) at 181. Ethylbenzene is highly volatile.

Have there been health effects attributed to ethylbenzene?

22. Although there is some indication that acute inhalation exposures to ethylbenzene at very high concentrations (1,000 parts per million or greater) can result in eye irritation, burning, and tearing (*see* FPL-037 (ATSDR, 2010) at 105), no studies involving ingestion of ethylbenzene at low concentrations in humans were located for review. Additionally, according to ATSDR, which is the premier governmental health authority in the U.S., the available studies involving ingestion of ethylbenzene in animals were either of poor quality or were not considered relevant to humans. FPL-037 (ATSDR, 2010) at 094-105. In any event, the study indicating that eye irritation due to ethylbenzene concentrations of 1,000 parts per million or greater in air clearly is not a concern here, given that according to FEIS Table 3-5 ethylbenzene was *not detected* (i.e., concentrations were below the MDL) in any of the wastewater samples analyzed from 2007 through 2011, and it also was not detected in the 2013 or 2014 sampling. NRC-008 (FEIS) at Table 3-5; *see* NRC-008 (FEIS) at 3-37. Consequently, there would be no human health risks associated with ethylbenzene from the Turkey Point wastewater.

Have the USEPA and FDEP established drinking water standards for ethylbenzene?

23. Yes. The health protective drinking water standard established by USEPA for ethylbenzene is 0.7 mg/L. FPL-054 (USEPA, 2016a) at 009; *see* Table 1 above. Similarly, the protective drinking water standard established by FDEP for ethylbenzene is 0.7 mg/L. FPL-053 (FDEP, 2015) at 054. Concentrations equal to or less than these standards are

considered safe for consumption in drinking water. The FEIS Table 3-5 concentration for ethylbenzene was below the MDL, so clearly it is well below both the federal and state safe drinking water standards.

What is toluene?

24. Toluene is a clear, colorless liquid under ambient conditions with a solvent odor. It occurs naturally in crude oil, many petroleum products, and is added to gasoline. It is widely used as a solvent and in the making of paints, paint thinners, fingernail polish products, lacquers, adhesives, and rubber products. Like ethylbenzene, toluene is very volatile. *See, e.g., FPL-034 (ATSDR, 2000) at 021, 139, 206.*

Have there been health effects attributed to toluene exposure?

25. Some health effects have been reported in animals exposed to toluene by ingestion. FPL-034 (ATSDR, 2000) at 099-115. However, the level at which nominal adverse effects were reported from ingestion exposure in those animal studies was 4 mg/kg•day. FPL-034 (ATSDR, 2000) at 106. That is more than *87,000 times* greater than the dose from exposure to toluene at the concentration set forth in FEIS Table 3-5, even if that wastewater was directly consumed as a drinking water source.⁶ Stated differently, even at doses 87,000 times greater than those which may be associated with the concentration in FEIS Table 3-5, no effects would be expected in animals or humans.

Have the USEPA and the FDEP established drinking water standards for toluene?

26. Yes. The health protective drinking water standard established by USEPA for toluene is 1 mg/L. FPL-054 (USEPA, 2016a) at 011; *see* Table 1 above. Similarly, the protective drinking water standard established by the FDEP for toluene is 1 mg/L. FPL-053 (FDEP, 2015) at 054. Concentrations equal to or less than these standards are considered safe for consumption in drinking water. The FEIS Table 3-5 concentration for toluene is 0.00174 mg/L, well below the federal and state safe drinking water standards.

⁶ I made this calculation using the following formula: Toluene Dose Ratio (87,471) = [LOAEL (4 mg/kg•day)] / [(0.00174 mg/L x 2 L/day Ingestion Rate) / 76.1 kg Body Weight]. The 2 L/day Ingestion Rate and 76.1 kg Body Weight are values used by federal and state agencies in the calculation of doses and potential risks from drinking water exposures.

What is tetrachloroethylene?

27. Tetrachloroethylene is a nonflammable, colorless liquid under ambient conditions, with a mildly sweet, chloroform-like odor. It is used as a solvent for dry cleaning and textile processing, as a degreasing and metal cleaning agent, and as a chemical intermediate. FPL-031 (ATSDR, 2014a) at 235, 237, 238; FPL-049 (HSDB, 2012) at 090, 112. Tetrachloroethylene is a volatile liquid under normal environmental conditions. FPL-031 (ATSDR, 2014a) at 243, 253. It is resistant to aerobic biodegradation. *Id.* at 259. However, it can be biodegraded anaerobically to trichloroethylene, dichloroethylenes, vinyl chloride, and ethylene gas through the process of reductive dechlorination by microbes that are biologically adapted to use tetrachloroethylene as an energy source. *Id.* at 259-260.

Have there been health effects attributed to tetrachloroethylene exposure?

28. While health effects from exposure to tetrachloroethylene have been described in the literature, as with the other chemicals described above the doses involved are much higher than would be associated with the concentrations listed in FEIS Table 3-5. For example, negative effects were seen in an infant exposed to breast milk with 10 mg/L of tetrachloroethylene (*see* FPL-031 (ATSDR, 2014a) at 135-136), which is nearly 2,800 times the maximum concentration listed in Table 3-5. Health effects observed at such a high concentration would not translate into similar, or indeed any, effects at the low concentrations set forth in Table 3-5. Accordingly, no adverse health effects are expected from exposure to tetrachloroethylene in the injectate water, even if it was consumed as a drinking water source.

Have the USEPA and FDEP established drinking water standards for tetrachloroethylene?

29. Yes. The health protective drinking water standard established by the USEPA for tetrachloroethylene is 0.005 mg/L. FPL-054 (USEPA, 2016a) at 011; *see* Table 1 above. The protective drinking water standard established by the FDEP for tetrachloroethylene is 0.003 mg/L. FPL-053 (FDEP, 2015) at 054. Concentrations equal to or less than these standards are considered safe for consumption in drinking water. The FEIS Table 3-5 concentration for tetrachloroethylene is 0.00359 mg/L, well below the federal safe drinking water standard and only a few ten thousandths of a mg/L above the state drinking water

concentration. As I explain below, the minor amount by which the concentration may exceed the state drinking water standard is of no health concern. In addition, the USEPA has issued an update to the agency health-based screening levels indicating that the protective default tapwater concentration for tetrachloroethylene should be 0.011 mg/L, which is well above the concentration at issue in this case. *See* USEPA Regional Screening Levels, May 2016, *available at* <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016>.

Are you aware of a previous modeling analysis which has been conducted for tetrachloroethylene in the context of deep well injection of wastewater containing that substance in Dade County?

30. Yes. I reviewed a document entitled “Relative Risk Assessment of Management Options for Treated Wastewater in South Florida” (FPL-027 (USEPA, 2003)), which addressed that issue. One of the modeling cases therein considered transport modeling of tetrachloroethylene contained in wastewater injected at a concentration of 0.00466 mg/L to a depth of 2,900 feet in Dade County under two flow scenarios. FPL-027 (USEPA, 2003) at 121, 126, 132. The first scenario assumed conventional porous media flow and concluded that tetrachloroethylene would not be detectable at either the base of the nearest USDW or at a hypothetical well installed to a depth of 100 feet below ground surface. FPL-027 (USEPA, 2003) at 121, 126, 132. The second scenario assumed potential bulk flow through preferential flow paths and concluded that tetrachloroethylene would be detectable at 0.00001 to 0.00002 mg/L at the hypothetical well or at the base of the nearest USDW, respectively. FPL-027 (USEPA, 2003) at 121, 126, 132. The latter detected concentrations, derived from a highly conservative transport scenario, both are far lower (150 to 500 times less) than either the federal MCL (0.005 mg/L) or the Florida MCL (0.003 mg/L) for tetrachloroethylene. It is reasonable to assume that injection of wastewater at 0.00359 mg/L tetrachloroethylene as in Table 3-5, versus 0.00466 mg/L as in the USEPA risk assessment, would yield even lower projected concentrations at the receptors, which also would not be of human health concern.

Regulatory Guidance for Chemicals of Interest

For each of the four chemicals of interest, you identified federal and state protective drinking water standards. How were those standards developed?

31. The drinking water standards for chemicals that I refer to above were developed under the Safe Drinking Water Act and National Primary Drinking Water Regulations applicable to public water systems. As noted above, primary standards protect public health by limiting levels of contaminants in drinking water. Assumptions underlying the drinking water standards are a consumption rate of 2 liters per day (2 L/day; about one-half gallon per day) and lifetime, unrestricted exposure.

Based on those standards, how would injectate containing the four chemicals at the concentrations listed on FEIS Table 3-5 impact the supply of drinking water?

32. Based on those standards, it is not reasonable to expect a detectable influence on the local drinking water supply from the four chemicals of interest, given the concentrations at issue. Indeed, even in the case of sporadic, occasional, or nominal values in excess of a drinking water standard (which my experience gives me no reason to expect here), a conclusion of a health hazard to the population is not warranted.
33. Federal drinking water standards for heptachlor, ethylbenzene, toluene, and tetrachloroethylene were discussed previously and are listed in Table 1 above. As can be seen from that Table, the concentrations of those chemicals proposed for injection into the Boulder Zone as set forth in the FEIS are all considerably less than their respective federal limits, indicating that those chemicals, at their maximum estimated concentrations, would not pose a health risk to the public even if directly injected into drinking water.
34. While the wastewater would be safe even if injected directly into the drinking water, the public health in this case will be even further protected due to dilution. Given the geological features described in the FEIS and the Testimony of Dr. Robert Maliva and Mr. David McNabb, it is reasonable to assume that wastewater injected into the Boulder Zone would be substantially diluted by the time it may migrate, if at all, to the UFA.
35. Moreover, due to the salinity of the water in the UFA in that region of Florida, it is not used directly for drinking water purposes without post-withdrawal treatment (NRC-008A

(FEIS, 2016) at 2-54), which in turn would serve to reduce even further the concentrations of the four chemicals of interest that are assumed to be present in the injectate.

36. For these reasons, to conclude that effects on the environment from the four chemicals of interest would be “small” actually greatly overstates the plausible impacts of the injection process.
37. Similar to the federal standards, state drinking water standards are applicable to these substances under the FDEP’s purview. The concentrations of heptachlor, ethylbenzene, and toluene estimated to occur in the wastewater proposed for injection into the Boulder Zone are all less than their respective state MCLs, indicating that those chemicals, even at the maximum estimated concentrations, would be acceptable even if present directly in drinking water.
38. The maximum estimated concentration of tetrachloroethylene nominally exceeds its state MCL by less than 19%. This small *potential* deviation from the state standard would have an insignificant impact on public health. As I described above, reports of adverse health effects from tetrachloroethylene have been attributed to doses significantly higher than would be associated with the concentrations listed in FEIS Table 3-5. As I also noted previously, the most recent USEPA values posted in the health-based Regional Screening Levels guidance, and considering the newest toxicological information regarding tetrachloroethylene, sets the appropriate tapwater concentration at 0.011 mg/L. That value is considerably greater than the Table 1 value for tetrachloroethylene in the injectate of 0.00359 mg/L. In addition, the concentrations in Table 3-5 do not consider the substantial dilution that will occur by the time the wastewater would migrate, if at all, to the UFA. Finally, the wastewater will pass through Turkey Point’s cooling system. As I described previously, tetrachloroethylene is quite volatile and is released rapidly from water, especially under circumstances where that water is heated and/or agitated, as would occur when the wastewater is used for cooling purposes. Consequently, concentrations of tetrachloroethylene, as well as the other volatile chemicals of interest in this instance, would be reduced to concentrations below the state drinking water standard in the wastewater that actually is injected into the Boulder Zone. Hence, the residual

concentrations of tetrachloroethylene and other chemicals of interest in this matter would not be of regulatory or human health interest.

Affidavits of Mr. Mark A. Quarles

Have you reviewed the Affidavits submitted previously in this proceeding by Mr. Mark Quarles?

39. Yes.

What is your assessment of Mr. Quarles' assertions regarding the potential health effects from exposure to the four chemicals of interest?

40. In his first affidavit dated January 23, 2012 (Quarles, 2012a), Mr. Quarles presented several statements regarding his views of potential health effects that he believes may be associated with exposure to the four chemicals of interest in this matter. Mr. Quarles also addressed these issues in a Declaration he submitted on August 3, 2012. *See* Quarles, 2012c. From a review of his CV, it appears that Mr. Quarles lacks education or training in the fields of toxicology and human health risk assessment, which likely explains his inaccurate and indefensible views regarding potential health hazards of the four chemicals of interest in the concentrations at issue. Neither Mr. Quarles' second or third affidavits (Quarles, 2012b; Quarles, 2016c) address toxicological issues.

Do you agree with Mr. Quarles' assessment of the potential health effects from exposure to heptachlor that could be present in the Turkey Point injectate?

41. No. In paragraph 27 on page 6 of his January 23, 2012 affidavit, Mr. Quarles indicated that heptachlor epoxide is a breakdown product of heptachlor. As I discuss above, it is possible for heptachlor to be hydrolyzed to some degree to 1-hydroxychloridene and heptachlor epoxide in water, while it also can be biodegraded to heptachlor epoxide by a number of species. It is first worth noting, however, that heptachlor epoxide is not itself a chemical present in the wastewater. It was not detected in any of the wastewater samples collected from 2007 through 2011, nor was it detected in the 2013 or the 2014 sampling. *See* NRC-008A (FEIS) Table 3-5.

42. In addition, the maximum calculated concentration of the parent chemical, heptachlor, that is estimated to be present in the wastewater for injection is 0.000023 mg/L. *See* NRC-008A (FEIS) Table 3-5. Consequently, the maximum concentration of heptachlor *epoxide* that could be present in the wastewater as a heptachlor breakdown product would be the same (0.000023 mg/L), assuming that all of the heptachlor concurrently was converted to heptachlor epoxide, and that no other degradation or removal processes were operating. A more sophisticated treatment of the question regarding what proportion of heptachlor might be converted to heptachlor epoxide would require modeling, which appears not to have been considered by Mr. Quarles in forming his opinion. That worst case concentration, however, still is about 10 times less than the USEPA and the FDEP drinking water standard for heptachlor epoxide (0.0002 mg/L), demonstrating that there would be no health concern or violation of a drinking water standard, even in the event that all of the heptachlor in the wastewater was converted to heptachlor epoxide at the same time (which is chemically implausible).
43. In paragraph 31 (page 7) of his January 23, 2012 affidavit, Mr. Quarles presented a list of health effects that he believes are attributable to heptachlor. Those listed effects were "possible human carcinogen, and immune and nervous system effects." Mr. Quarles referred to an ATSDR ToxFAQ information sheet that was included as an attachment to his affidavit, as the source of that information. Quarles, 2012a, at 151-152. But, according to the document Mr. Quarles references, there is no reliable information on the health effects of heptachlor in humans, which would include possible carcinogenic effects. FPL-036, (ATSDR, 2007b) at 002; *see also* FPL-038 (ATSDR, 2007c) at 025-026. While heptachlor is classified as a "possible human carcinogen" according to ATSDR (FPL-036 (ATSDR 2007b) at 002), the USEPA and the FDEP drinking water MCL for heptachlor takes that characteristic into account. Moreover, the immune and nervous system effects listed by Mr. Quarles were reported in animals, and as I explained above, only at doses that are far above those that would be associated with potential concentrations in a drinking water scenario here. FPL-036 (ATSDR, 2007b) at 001-002; FPL-038 (ATSDR, 2007c) at 060-061.
44. Further, for each of the studies that reported noncarcinogenic adverse immune or nervous system effects at certain exposure levels, those same studies also reported exposure levels

at which there were no observed adverse effects (1 mg/kg•day). FPL-038, (ATSDR, 2007c) at 051. Both the federal and state drinking water standards, and the concentration of heptachlor at issue in this case, fall far below this level which caused no adverse effects. Accordingly, Mr. Quarles' concern regarding heptachlor is misplaced.

Do you agree with Mr. Quarles' assessment of the potential health effects from exposure to ethylbenzene that could be present in the Turkey Point injectate?

45. No. In paragraph 31 on page 7 of his January 23, 2012 affidavit, Mr. Quarles presented a list of health effects that he believes are attributable to ethylbenzene. Those listed effects were "possible human carcinogen and kidney damage." The 2007 ATSDR ToxFAQ (FPL-032 (ATSDR, 2007a)) cited by Mr. Quarles states that health effects of exposure to ethylbenzene have been reported to include kidney damage in animals. However, those reported effects occurred from *inhalation* exposure, not ingestion exposure, which is the relevant exposure route in Turkey Point's case. FPL-032 (ATSDR, 2007a) at 001. Further, for each of the studies that reported adverse kidney effects at certain concentrations from oral exposure, those same studies also reported levels at which there were no observed adverse effects. FPL-037 (ATSDR, 2010) at 095-097. As I discussed above, both the federal drinking water standard and the concentration of ethylbenzene at issue in this case fall far below these levels which caused no adverse effects.
46. Furthermore, ethylbenzene is not judged to be a carcinogen by the USEPA (FPL-050 (IRIS, 1991) at 014), or by the FDEP (FPL-040 (FDEP, 2005) at 170). And, according to ATSDR 2010 (FPL-037 at 102), the few studies involving kidney effects from ingestion of ethylbenzene in animals were either of poor quality or not considered relevant to humans.
47. Accordingly, Mr. Quarles' concern regarding ethylbenzene is misplaced. Moreover, and perhaps of greater importance, concerns regarding exposure to ethylbenzene from Turkey Point injectate are not relevant since ethylbenzene was not detected in any of the available wastewater sample data. NRC-008A (FEIS) Table 3-5, notes (a) and (b).

Do you agree with Mr. Quarles' assessment of the potential health effects from exposure to toluene that could be present in the Turkey Point injectate?

48. No. In paragraph 31 on page 7 of his January 23, 2012 affidavit, Mr. Quarles presented a list of health effects that he believes are attributable to toluene, according to an ATSDR ToxFAQ document. FPL-039 (ATSDR, 2001) at 001. Those listed effects were "nausea and effects on the nervous system." In my experience, those effects can be associated with inhalation exposures but are not associated with parts per billion concentrations in water supplies. According to the most recent ToxFAQ for toluene that I retrieved from the ATSDR website, toluene is not frequently detected in drinking water (FPL-035 (ATSDR, 2015) at 001), and it rarely is observed there at levels of health interest, even when it is detected. Both of the ToxFAQs versions correctly indicate that symptoms of toluene exposure usually resolve when exposure is stopped. FPL-039 (ATSDR, 2001) at 002; FPL-035 (ATSDR, 2015) at 001. With respect to the oral exposure route (e.g., drinking water), for the intermediate duration neurological endpoint for which effects were reported by ATSDR, those same studies also reported a lowest observed adverse effect level of 5 mg/kg•day for the same effect. FPL-034 (ATSDR, 2000) at 105. Both the federal drinking water standard and the concentration of toluene at issue in this case represent doses which fall far below this lowest level which caused even nominal effects in animal studies.
49. In addition, nausea was reported in humans only in instances involving inhalation exposure to toluene in workplace air. FPL-034 (ATSDR, 2000) at 065. Exposure in that instance was within a group of 42 workers that were exposed to an uncharacterized solvent mixture (FPL-034 (ATSDR, 2000) at 065), which precludes establishing a causal relationship with toluene because one or more of the other solvents may have caused or contributed to the nausea.
50. Finally, as I discuss above, the potential for health effects from exposure to toluene in Turkey Point's injectate water is negligible, since the detections were well below federal and state drinking water standards. For these reasons, Mr. Quarles' concern regarding toluene is misplaced.

Do you agree with Mr. Quarles' assessment of the potential health effects from exposure to tetrachloroethylene or its breakdown products that could be present in the Turkey Point injectate?

51. No. First, in paragraph 28 on page 6 of his January 23, 2012 affidavit Mr. Quarles indicated that trichloroethylene and vinyl chloride are breakdown products of tetrachloroethylene. While that is accurate in some circumstances, as I stated above tetrachloroethylene hydrolyzes only very slowly, even at elevated temperatures and high pH, and it is resistant to aerobic biodegradation. While it can be biodegraded anaerobically to trichloroethylene and vinyl chloride, that process typically requires microbes that are adapted to tetrachloroethylene. Even in circumstances where tetrachloroethylene is shown to degrade to trichloroethylene and/or vinyl chloride, the formation of the two degradation products occurs slowly and at much lower concentrations than the parent tetrachloroethylene. In addition, vinyl chloride was not detected in any water sample here. Trichloroethylene was detected in two water samples collected from 2007 (FPL-052 (KSA) 2007), but not in other samples collected through 2011 (FPL-047 (Genapure, 2008); FPL-048 (Genapure, 2009); FPL-055 (Xenco, 2010); FPL-056 (Xenco, 2011)), and even then it was not detected at levels that are of health interest because they were well below the federal and state drinking water standards for trichloroethylene (0.005 mg/L and 0.003 mg/L, respectively). Thus, Mr. Quarles' conclusions, that trichloroethylene and/or vinyl chloride are of potential health concern, are without merit.
52. In paragraph 31 on page 7 of his January 23, 2012 affidavit, Mr. Quarles presented a list of health effects he believes are attributable to tetrachloroethylene. Those listed effects were "probable human carcinogen, nausea, liver damage, impaired heart function, and death." Mr. Quarles referred to a 1997 ATSDR ToxFAQ that was included as an attachment to his affidavit, as the source of that information. According to that ToxFAQ (FPL-030 (ATSDR, 1997)), and a more recent 2014 version that I retrieved from the ATSDR website, impaired heart function was not indicated as a potential health effect, and liver effects were only reported in animal studies. FPL-033 (ATSDR 2014b) at 001.
53. According to USEPA (FPL-051 (IRIS, 2012)), tetrachloroethylene is classified as likely to be carcinogenic in humans, and that factor is addressed in establishment of the state and the federal MCLs. However, while "nausea" is listed as a possible health impact by the

summary ToxFAQs (*see* FPL-030 (ATSDR, 1997) at 001; FPL-033, (ATSDR 2014b) at 001), the underlying document from which both of those documents were created *does not* report nausea as a potential health effect from exposure by any route (instead only describing one report of vomiting in boys treated with unspecified oral doses of tetrachloroethylene to remove intestinal worms). With respect to liver damage, as noted previously a single case of obstructive jaundice and hepatomegaly was reported in an infant exposed to tetrachloroethylene at 10 mg/L in breast milk. FPL-031 (ATSDR, 2014a) at 135-136. However, that concentration of tetrachloroethylene (assuming it was present in drinking water) is approximately *2,800 times* greater than the concentration of tetrachloroethylene set forth in FEIS Table 3-5.

54. In addition, it is not clear why Mr. Quarles would list "death" as a potential health effect from exposure to tetrachloroethylene, since that effect would be of interest from a highly unusual acute exposure perspective that is not relevant to the very low concentrations of tetrachloroethylene that conceivably could exist in the reclaimed wastewater. For these reasons, Mr. Quarles' concern regarding tetrachloroethylene is misplaced.

Are the four chemicals of interest harmful to humans in "minute concentrations"?

55. No. In paragraph 31 (page 7) of his January 23, 2012 affidavit (Quarles, 2012a), Mr. Quarles alleged that the four chemicals of interest are harmful to humans at "minute concentrations." That statement is inaccurate and misinformed. It indicates a fundamental misunderstanding and/or ignorance of the effects caused by these substances, and the doses at which potential effects may, or may not, occur.
56. A generally accepted principle in the discipline of toxicology is that the simple presence of an agent, including these four substances, in an environmental medium such as water is not sufficient to assess exposure or significance of potential exposure. It is essential in such cases to determine a potential dose based on measured or calculated chemical concentrations and intake rates compared to health-based risk guidelines, to assess whether an actual health risk may exist. In this instance, concentrations of the four chemicals of interest listed in FEIS Table 3-5 are all below their respective federal MCLs, indicating that those concentrations are protective of public health from a drinking water perspective.

Conclusions & Opinions

Please summarize your conclusions and opinions.

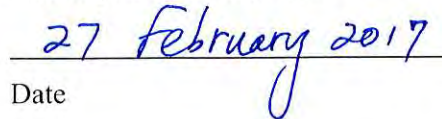
57. Based on my education, training, and over three decades of experience as a professional toxicologist, as well as my review of information specific to this matter, in my professional opinion a contention that the FEIS is rendered deficient by its conclusion that environmental impacts related to the four chemicals of interest will be “small” is wholly unfounded. Not only will impacts certainly be no greater than “small,” in my opinion even that characterization greatly overstates the case. The available information supports a conclusion that the influence, if any, will be undetectable.
58. Even assuming heptachlor, ethylbenzene, toluene, and tetrachloroethylene are present in the wastewater at concentrations listed in FEIS Table 3-5, and to the extent that the water hypothetically could reach a drinking water source directly or following migration from the Boulder Zone, it would have no water quality impact from a human health perspective.
59. It is also my opinion that, since the concentrations of the four chemicals of interest in the wastewater proposed for injection into the Boulder Zone are all below federal drinking water standards, the public health is protected.
60. Furthermore, even if an unreasonable assumption is made that the injectate was used directly as a drinking water source, exposure to the four chemicals of interest would be far less than that which has been reported in the literature to cause adverse health effects and, thus, they are not of toxicological significance.
61. Concerns regarding potential health effects from exposure to the breakdown products of heptachlor and tetrachloroethylene also are unfounded. Reported analytical results for those two substances for 2007 through 2011, as well as for 2013 and 2014, indicated detectable concentrations in wastewater on only one date for trichloroethylene and never for heptachlor epoxide. Those trichloroethylene concentrations, as with the other substances of interest, were all below federal drinking water standards.
62. For these reasons, I concur with the FEIS determination that the environmental impact of injected wastewater from Turkey Point will be “small” (*See* NRC-008A (FEIS) at 5-41, 5-

42), if any. The concentrations of the four chemicals of interest in the wastewater will not adversely affect public health.

I, Christopher M. Teaf, swear under penalties of perjury that the foregoing Testimony is true and correct to the best of my knowledge and belief.

A handwritten signature in blue ink, reading "Christopher M. Teaf", written over a horizontal line.

Christopher M. Teaf, Ph.D.

A handwritten date in blue ink, "27 February 2017", written over a horizontal line.

Date

Attachment A

CURRICULUM VITAE

NAME: Christopher Morris Teaf

DATE OF BIRTH: 5 May 1953

PLACE OF BIRTH: Philadelphia, PA

HOME ADDRESS: 499 Frank Shaw Road
Tallahassee, FL 32312
(850) 933-0963 (*cell*)

MARITAL STATUS: Married, two children

PROFESSIONAL POSITIONS: Director
Center for Biomedical & Toxicological Research and Waste Management
Florida State University
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President & Director of Toxicology
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Tallahassee, FL 32309
(850) 681-6894 *phone*
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cteaf@hswmr.com *email*

EDUCATION: Ph.D. Toxicology 1985
University of Arkansas for Medical Sciences

M.S. Biological Science 1980
Florida State University

B.S. Biology 1975 (*with Honors*)
Pennsylvania State University

PROFESSIONAL MEMBERSHIPS: Academy of Toxicological Sciences
Florida Bar, Environmental and Land Use Law Section
International Society for Technical & Environmental Professionals
National Association of Environmental Professionals
National Association of Underwater Instructors
Society of Toxicology
Society for Environmental Toxicology and Chemistry
Society for Risk Analysis

CERTIFICATIONS: Board Certified Fellow, Academy of Toxicological Sciences (ATS)
Radon Measurement Specialist (*Florida DOH R1032*)

ACTIVITIES & HONORS:

Co-Editor-in-Chief, *Journal of Soil & Sediment Contamination*, Taylor & Francis. 2015 to present.

Board Member, Coastal Conservation Association (CCA), Big Bend Chapter. 2014 to present.

Board of Directors, Dog Island Conservation District. 2002 to present (*Chair, 2004 to 2015; Treasurer 2015 to present*).

Board Certified as a Fellow, Academy of Toxicological Sciences. 2009 to present.

Radon Measurement Specialist (*FL HRS Certification R1032*), 1989 to present.

Science Advisory Board, 33rd International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2017. (*Also Risk Assessment Subcommittee member*).

District 2 Local Emergency Planning Committee, Florida Emergency Response Commission, 1987 to present (*Vice Chair, 1991*).

Technical Peer Reviewer: *Human & Ecological Risk Assessment* (1999-present); *Nonlinearity in Biology, Toxicology and Medicine* (2005-present); *Ohio Journal of Science* (1988-1992); *Bulletin of Marine Science* (1994-1998); *Environmental Toxicology & Chemistry* (1997-present); *Environmental Biology of Fishes* (1987-1990), *Soil & Sediment Contamination* (2002-present), *Environmental Forensics* (2006-present).

Co-Editor, Joint Proceedings of the 26th West Coast and 32nd East Coast Annual International Conferences on Soil, Sediments, Water & Energy. Association for Environmental Health & Sciences (AEHS). March, 2016 (San Diego, CA) and October 2016 (Amherst, MA).

Editorial Board, *Human & Ecological Risk Assessment*, published by Taylor & Francis. 2000 to present (*Senior Human Health Editor, 2004 to 2015*).

Science Advisory Board, 32nd International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2016. (*Also Risk Assessment Subcommittee member*).

Co-Editor, Joint Proceedings of the 25th West Coast and 31st East Coast Annual International Conferences on Soil, Sediments, Water & Energy. Association for Environmental Health & Sciences (AEHS). March, 2015 (San Diego, CA) and October 2015 (Amherst, MA).

Science Advisory Board, 31st International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2015. (*Also Risk Assessment Subcommittee member*).

Human Health Peer Review Committee. FL Department of Environmental Protection. 2012 to present.

Co-Editor, Proceedings of the 30th Annual International Conference on Soil, Sediments, Water & Energy. Association for Environmental Health & Sciences (AEHS). October 2014. Amherst, MA.

Co-Editor, Proceedings of the 30th Annual International West Coast Conference on Soil, Water, Energy & Air. March 2014. San Diego, CA.

Science Advisory Board, 30th International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2014. (*Also Risk Assessment Subcommittee member*).

Peer Reviewer, Doctoral Dissertation Committee, Office of the Dean, University of British Columbia, Vancouver, BC. 2014. (*Dr. Maryam Khoshnoodi*).

Co-Editor, Proceedings of the 29th Annual International Conference on Soil, Sediments, Water & Energy. Association for Environmental Health & Sciences (AEHS). October 2013. Amherst, MA.

Co-Editor, Proceedings of the 23rd Annual International West Coast Conference on Soil, Water, Energy & Air. March 2013. San Diego, CA.

Science Advisory Board, 29th International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2013. (*Also Risk Assessment Subcommittee member*).

Co-Chair, Human Health Session, Fourth Annual International Symposium & Exhibition on the Redevelopment of Manufactured Gas Plant Sites (MGP 2012). Chicago IL. March 28-30, 2012.

Co-Editor, Proceedings of the 28th International Conference on Contaminated Soils, Sediments & Water, October 2012. Amherst, MA.

Senior Fellow, Environmental Health & Safety. Center for Risk Communication. New York, NY and Stevens Point, MD. 2011 to present.

Science Advisory Board, 28th International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. October, 2012. (*Also Risk Assessment Subcommittee member*).

Co-Editor, Proceedings of the 27th International Conference on Contaminated Soils, Sediments & Water, October 2011. Amherst, MA.

Certificate of Appreciation. Cascades Park Former MGP Site. U.S. EPA Region 4. Atlanta, GA.

Editorial Board, int'l journal *Environmental Forensics*, Taylor & Francis Publishers, 2006 to present.

Advisory Board, Center for Strategic Health Preparedness, Florida State University College of Medicine. 2001 to present. (*formerly Center for Terrorism & Public Health*)

Science Advisory Board, 27th International Conference on Contaminated Soils, Sediments & Water, 2011. Amherst, MA.

Science Advisory Board, 26th International Conference on Contaminated Soils, Sediments & Water, 2010. Amherst, MA.

Science Advisory Board, 25th International Conference on Contaminated Soils, Sediments & Water, 2009. Amherst, MA.

Science Advisory Board, 24th International Conference on Contaminated Soils, Sediments & Water, 2008. Amherst, MA.

Science Advisory Board, 23rd International Conference on Contaminated Soils, Sediments & Water, 2007. Amherst, MA.

Science Advisory Board, 22nd International Conference on Contaminated Soils, Sediments & Water, 2006. Amherst, MA.

Science Advisory Board, 21st International Conference on Contaminated Soils, Sediments & Water, 2005. Amherst, MA.

Editorial Board, international journal *Soil & Sediment Contamination*, CRC Press, LLC. 2002 to 2006.

Science Advisory Board, 20th International Conference on Contaminated Soils, Sediments & Water, 2004. Amherst, MA.

Courtesy Professor, Department of Geology, Florida State University. 1999 to present.

Science Advisory Board, 19th International Conference on Contaminated Soils, Sediments & Water. Amherst, MA. 2003.

Science Advisory Board, 18th International Conference on Contaminated Soils, Sediments & Water. 2002. Amherst, MA.

Co-Director, NATO Advanced Research Workshop on Risk Assessment and Water Issues in Central Asia. 2000 to 2003. Almaty, Kazakhstan. 2000 to 2003.

Science Advisory Board, 17th International Conference on Contaminated Soils, Sediments & Water. 2001. Amherst, MA.

Advisory Board, International Congress on Petroleum Contaminated Soils, Sediment & Water. London. 2000-2001.

Advisory Board, 16th International Conference on Contaminated Soils, Sediments & Water. 2000. Amherst, MA.

Assistant Scoutmaster, Troop 44. Tallahassee, FL. 1998 to 2004.

Editorial Board, *Environmental Toxicology & Chemistry*, published by CRC Press, LLC. 2003-2005.

Petroleum Underground Storage Tanks Technical Committee, Florida Department of Environmental Protection. 1996 - 2015.

Advisory Board, 15th Int'l Conf. on Contaminated Soils, Sediments & Water. Amherst, MA. 1998-1999.

Toxic Substances Advisory Council, Florida Department of Labor. 1990-2000 (*Chair, 1991-1996*).

Florida Bar, Environmental and Land Use Law Section Faculty and Steering Committee, 1996 - 1997.

Safety Committee, Florida Department of Environmental Protection, 1995 – 1997 (*advisor 1995-present*).

Florida Bar, Environmental and Land Use Law Section Faculty and Steering Committee, 1993 - 1994.

Technical Committee, MGP '95-Int'l Symposium on Cleanup of MGP Sites. Prague, Czech Republic, 1994-1995.

Florida Comparison of Environmental Risks Project, 1994-1995 (*Human Health Co-chair*).

Landfill Technical Advisory Group, Florida Department of Environmental Protection, 1993-1994.

Benlate Health Effects Committee, Pesticide Review Council, Florida Department of Agriculture, 1993-1995.

Technical Advisory Committees for Budapest '92, Budapest '94, Warsaw '96, Warsaw '98, Prague 2000, Prague, 2003; International Symposia on Environmental Contamination in Central & Eastern Europe. 1991-2004.

Financial & Technical Advisory Committee, Florida Department of Environmental Protection. 1986-1992.

Director, Tallahassee Marathon/Half Marathon, 1989, 1990, 1991, 1995.

Outstanding Research Award, University of Arkansas Medical School, 1984.

Who's Who Among American College Students, 1983.

Graduation With Honors, Pennsylvania State University, 1975.

National Merit Scholar Program, 1971.

Eagle Scout, 1969 (*Troop 1, Boy Scouts of America; Paoli, PA; Assistant Scoutmaster 1971 to 1975*)

SUMMARY OF ACTIVITIES

Dr. Teaf received a BS (Biology) from Penn State with Honors, an MS (Biological Science) from Florida State (FSU), and a Ph.D. (Toxicology) from the University of Arkansas for Medical Sciences. He conducted his research at the National Center for Toxicological Research. His experience includes positions of Director (and Associate Director) of the FSU Center for Biomedical & Toxicological Research and Hazardous Waste Management (1983-present), and Director of Toxicology for HSWMR, Inc. since 1985 (President since 1989). From 1980 to 1982 he served as Research Staff for the Florida Governor's Hazardous Waste Policy Advisory Council. Dr. Teaf is Board Certified as a Fellow by the Academy of Toxicological Sciences and certified as a Radon Measurement Specialist by the Florida Department of Health.

Research and professional activities include: toxicology and risk assessment for exposure to occupational or environmental chemicals under OSHA, CERCLA, SARA, RCRA, TSCA, and related state/federal legislation (e.g., solvents, petroleum, PAHs, arsenic, mercury, lead and other metals, radionuclides, pesticides, particulates, biological agents); drugs and alcohol; male reproductive toxicity; aquatic toxicology; waste management. Dr. Teaf has been peer reviewer for e.g., *Risk Analysis*; *Environmental Forensics*; *Nonlinearity in Biology, Toxicology & Medicine*; *Environmental Toxicology & Chemistry*; *Integrated Environmental Assessment & Management*; *Bulletin of Marine Science*; *Ohio Journal of Science*; *European Journal of Public Health*; *Chemosphere*; *Environmental Biology of Fishes*; *Soil & Sediment Contamination*, reviews of research submitted to Agency for Toxic Substances and Disease Registry (ATSDR), and book reviews. He is Co-Editor-in-Chief for the journal *Soil & Sediment Contamination*, and is on the Editorial Board of *Environmental Forensics*, and for *Human & Ecological Risk Assessment*.

Chris has directed or conducted research for the U.S. Environmental Protection Agency (USEPA), U.S. Department of Agriculture (USDOA), and Florida agencies: Department of Labor, Department of Environmental Protection (FDEP), Department of Health (FDOH), and Department of Community Affairs. He served as toxicologist to the Governor's Financial & Technical Advisory Committee, and for the state Landfill Technical Advisory Group. He served as toxicologist for the state Petroleum Underground Storage Tanks Technical Advisory Committee. He was Co-chair of the Human Health Committee, Florida Comparison of Environmental Risks Project, a cooperative study funded by USEPA, FDEP and other agencies. He served as Chair of the Toxic Substances Advisory Council for the Florida Department of Labor, implementing the state Right-to-Know Law. Dr. Teaf is toxicologist for and served as Vice-Chair of the District 2 Local Emergency Planning Committee (State Emergency Response Commission). From 1986-1989, he was liaison for the State University System of Florida Toxicological Research Coordinating Committee and FDEP. He has been actively involved in the U.S. and abroad on chemical terrorism. Since 1998, Chris has been actively involved in the statewide Contaminated Soils Forum, interacting with FDEP on soil contamination issues. He has served on graduate committees at Florida A&M University, Georgia Tech, and University of British Columbia.

Chris has taught graduate and undergraduate courses at FSU, Florida A&M, University of Florida, and Georgia Tech. He has organized and participated in seminars and training courses for groups including the World Health Organization (WHO), USEPA, NASA, USDOA, ATSDR, FDOH, Florida Engineering Society, Florida Bar Association, FDEP, Florida Department of Education, Florida Chamber of Commerce, National Conference on Waste Exchange & Resource Reuse, National Hazardous Materials Training Center, and American Bar Association. He has served on Advisory Committees for MGP '95 (International Symposium on Cleanup of Manufactured Gas Plants; Prague), and for 6 International Symposia on Environmental Contamination in Central & Eastern Europe (Budapest, Warsaw, Prague). Chris has been involved in several extensive risk-based initiatives under the auspices of the World health organization (WHO) and the North Atlantic Treaty Organization (NATO) in Central & Eastern Europe (*Poland, Hungary, Bulgaria*) and in Central Asia (*Kazakhstan*)

Dr. Teaf has provided technical services on toxicology, environmental and human health risk assessment, waste management, recycling, water quality, consumer product safety and occupational health/safety, particularly regarding the OSHA Hazard Communication Standard, Florida Right-to-Know Law and federal requirements under RCRA, CERCLA, TSCA or related state regulations, including CERCLA cost allocations. He has provided service to U.S. Attorney, and Florida State Attorney, as well as Attorneys General of Florida, Washington, Oklahoma. Dr. Teaf has testified on environmental issues, alcohol/drugs, occupational exposures, health effects, mold, consumer products and risk assessment to regulatory, administrative, legislative or judicial bodies (*federal, state court*).

SUMMARY OF PROFESSIONAL POSITIONS:

Director of Toxicology
Hazardous Substance & Waste Management Research, Inc. (HSWMR; Tallahassee, FL)
1985 to present (President, 1989 to present)

Director
Center for Biomedical & Toxicological Research and Waste Management
Florida State University (Tallahassee, FL)
2016 to present

Associate Director
Center for Biomedical & Toxicological Research and Waste Management
Florida State University (Tallahassee, FL)
1983 to 2016

Advisory Committee
Professional Masters Program Development
Florida State University Department of Oceanography
2010 to present

Advisory Board
Center for Strategic Public Health Preparedness (*formerly Center for Terrorism & Public Health*)
Florida State University College of Medicine
2001 to present

Adjunct Faculty
College of Pharmacy & Pharmaceutical Sciences
Florida A & M University (Tallahassee, FL)
1998 to present

Board Member
Dog Island Conservation District
Franklin County, Florida
2002 to present (Chair, 2004 to 2015; Treasurer, 2015 to present)

Board of Directors
Southern Waste Information Exchange (Tallahassee, FL)
2000 to present (Chair, 2000 to 2004)

Toxicologist
Human Health Peer Review Committee
Florida Department of Environmental Protection (Tallahassee, FL)
2012 to 2016

Associate in Medicine
Program in Medical Sciences / FSU Medical School
Florida State University (Tallahassee, FL)
1995 to 2002

Toxicologist
Toxic Substances Advisory Council
Florida Department of Labor & Employment Security (Tallahassee, FL)
1990 - 1998 (Chairman, 1992 to 1998)

Toxicologist
Petroleum Underground Storage Tanks Advisory Committee
Florida Department of Environmental Protection (Tallahassee, FL)
1996 to present

Toxicologist
District 2 Local Emergency Planning Committee
Florida Department of Community Affairs (Tallahassee, FL)
1987 to present (Vice Chairman, 1991)

Toxicologist
Florida Landfill Technical Advisory Group
Florida Department of Environmental Protection (Tallahassee, FL)
1993 - 1994

Adjunct Faculty
Interdisciplinary Toxicology Program
University of Arkansas for Medical Sciences (Little Rock, AR)
1986 - 1989

Toxicologist
Governor's Financial and Technical Advisory Committee
Florida Department of Environmental Regulation (Tallahassee, FL)
1986 - 1992

Research Assistant
National Center for Toxicological Research and the University
of Arkansas for Medical Sciences (Little Rock, AR)
1983 - 1985

Associate Director
Southern Waste Information Exchange (Tallahassee, FL)
1981 - 1983

Research Staff
Florida Governor's Hazardous Waste Policy Advisory Council
1980 - 1982

Research Associate, Hazardous Waste Management Program
Florida State University (Tallahassee, FL)
1979 - 1983

Teaching/Research Assistant
Departments of Biological Science and Oceanography
Florida State University (Tallahassee, FL)
1976 - 1980

Animal Technician
Wyeth Laboratories (Philadelphia, PA)
1975 - 1976

TEACHING EXPERIENCE:

Air Quality (*Indoor/Outdoor*)
Alcohol, Smoking, Medicinal & Recreational Drugs: Toxicology and Exposure
Aquatic Toxicology
Carcinogenesis and Carcinogens
Comparative Vertebrate Morphology
Dermal Toxicology
Emergency Response and Contingency Planning
Environmental Hazards, Environmental Chemistry & Behavior of Chemicals
Exposure Assessment
General Zoology
Hazardous Waste Management
Health and Safety for Site Investigation and Response Personnel (*40 Hr and 8 Hr*)
Ichthyology
Inhalation Toxicology
Industrial and Occupational Toxicology
Industrial Health & Safety
Landfills: Chemistry, Potential Health Risk, Environmental Management & Remediation
Metals Toxicology (*e.g., arsenic, lead, mercury, nickel, vanadium, cadmium, chromium*)
Mutagenesis
Nephrotoxicity
Airborne Particulates
Right-to-Know and Hazard Communication Laws (*OSHA and state*)
Pesticide Toxicology
Principles of Toxicology and Risk Assessment
Radionuclides and Radiation Toxicology
Reproductive Toxicology
Research Diving Techniques
Seafood Safety: Health Effects from Contaminated Products
Toxicology of Solvents and Other Organic Hydrocarbons
Toxicological Risk Assessment
Toxicology and Management of Mixed Wastes (*Chemical/Radiological*)
Toxicology for Physicians, Nurses, and Other Public Health Personnel
Vapor Intrusion: Evaluation and Health Significance

Single day events to full semester graduate/undergraduate courses at University of Florida, University of North Florida, Florida A & M University, University of Arkansas, Georgia Tech, Tallahassee Community College, Florida State University (Biology, Chemistry, Engineering, Geology, Oceanography, Urban & Regional Planning Depts.)

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Caspary, J., C.M. Teaf, C.M., J. Applegate, S. Folsom, C. Noble, M. Petrovich, J. Ullo, B. Dougherty and B. Moore. 2017. Update on Rule 62-780, 62-777, and the Contaminated Media Forum. 3rd Annual Winter Water Seminar. Florida Engineering Society. Tallahassee, FL. January, 2017.

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S. Simpson, G. Council, T. Ijaz, D.J. Covert and C.M. Teaf. 2016. Soil Cleanup Goal for Dioxin Using Probabilistic Risk Assessment Techniques. *Soil & Sediment Contamination* 25(7): 824-836.

Teaf, C.M., D.J. Covert, B.J. Tuovila, M.M. Garber. 2016. Amines in the Environment: Sources, Chemistry, Behavior and Toxicological Risk Considerations. 32nd Annual International Conference on Soils, Sediments, Water and Energy. Amherst, MA. October, 2016. *Also served as Session Moderator for Risk Assessment technical session.*

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DeMeo, R.A. , C.M. Teaf, P. Cornais, D. Stubbs, J. Oliveros, J. Applegate, H. Nelson, and S. Hilfiker. 2015. Practical Applications of Changes to Florida DEP's Risk-based Corrective Action Program. 29th Environmental Summer School Program, Florida Chamber of Commerce. July, 2015. Orlando, FL.

Teaf, C.M., B. Magee, S. Kane Driscoll, and C. Menzie. 2015. Risk-based Issues Confronting Assessment & Remediation at Historical Manufactured Gas Plant Sites. Panel presentation at MGP 2015. Providence, RI. April, 2015. *Also served as Session Moderator.*

Gasinski, C.M., E.W. Anderton, W.B. Taylor, D.J. Covert, W.D. Vogelsong, and C.M. Teaf. 2015. Risk-based Engineering Considerations Addressing Mixed Use Planning and Redevelopment at a Former MGP Site in Florida. *Presented at MGP 2015. Providence, RI. April, 2015.*

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SELECTED CONFERENCES AND TRAINING COURSES:

Personnel OSHA Health and Safety Refresher Training Courses (8 hours). 2017. For Florida Department of Environmental Protection. Tallahassee, FL. Scheduled for May 11 and May 16, 2017.

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Annual Large Quantity Generators Hazardous Waste Training. 2017. (*Toxicology & Exposure Guidelines session*). For Florida Department of Environmental Protection, Northeast District Office. Jacksonville, FL. January, 2017.

24 Hour Health & Safety Refresher Course (*Toxicology & Exposure Guidelines session*). 2016. For Florida Department of Environmental Protection, Northeast District Office. Jacksonville, FL. November, 2016.

Personnel OSHA Health and Safety Refresher Training Courses (8 hours). 2016. For Florida Department of Environmental Protection. Tallahassee, FL. May 3 and May 12, 2016.

Toxicology, Exposure Considerations, and Regulatory Considerations of 1,4-Dioxane. Northeast Waste Management Officials Association (NEWMOA). Three course offerings in Danielson, CT; Westford, MA; and Lebanon, NH. September and December, 2015.

8 Hour Health & Safety Refresher Course (*Toxicology & Exposure Guidelines session*). For Florida Department of Environmental Protection, Northeast District Office. Jacksonville, FL. September, 2015.

Personnel OSHA Health and Safety Refresher Training Courses (8 hours). 2015. For Florida Department of Environmental Protection. Tallahassee, FL. Two offerings in April, 2015.

8 Hour Health & Safety Refresher Course (*Toxicology & Exposure Guidelines session*). For Florida Department of Environmental Protection, Central District Office. Orlando, FL. April, 2015.

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Tuovila, B.J. and C.M. Teaf. 2014. Environmental Occurrence and Regulation of Historical Fumigants 1,2-Dibromoethane and 1,2-Dibromo-3-chloropropane. 30th Annual International Conference on Soils, Sediments, Water and Energy. Amherst, MA. October, 2014.

Personnel OSHA Health and Safety Refresher Training Courses (8 hours). 2014. For Florida Department of Environmental Protection. Tallahassee, FL. April, 2014 and May 2014.

Teaf, C.M. and B.J. Tuovila. 2013. Evaluation of reported health effects associated with a hydrochloric acid spill in a neighborhood setting. 29th Annual International Conference on Soils, Sediments, Water and Energy. Amherst, MA. October, 2013.

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Frazier, K.D., M. Clarkson, C.A. Wist, and C.M. Teaf. 2013. Blood, Sweat & Hair: Overview of Hazards & Employer Notification for Drugs in the Workplace. Annual Workplace Strategies Symposium, New Orleans, LA. May, 2013.

Teaf, C.M. and D.J. Covert. 2013. Perfluorinated compounds: Potentially applicable soil screening levels for the contaminant du jour. *29th Annual International Conference on Soils, Sediments, Water and Energy*. Amherst, MA. October, 2013.

Teaf, C.M. and M.M. Garber. 2013. Challenges related to 1,4-dioxane characterization, evaluation and treatment: Three case examples. *29th Annual International Conference on Soils, Sediments, Water and Energy*. Amherst, MA. October, 2013. *Also served as Session Moderator*.

Personnel Health and Safety Refresher Training Course (8 hours). 2013. For Florida Department of Environmental Protection. Tallahassee, FL. April, 2013 and May 2013.

Personnel Health and Safety Refresher Training Course (8 hours). 2012. For Florida Department of Environmental Protection. Tallahassee, FL. April, 2012 and May 2012.

Fourth Annual International Symposium & Exhibition on the Redevelopment of Manufactured Gas Plant Sites (MGP 2012). 2012. Chicago IL. March, 2012. *Also served as Symposium Co-Chair*.

Teaf, C.M. and M.M. Garber. 2011. Mercury Exposure Considerations: Evaluating the Chemical Form and Activities of the Individual. Presented at the 27th Annual International Conference on Soils, Sediments and Water. Amherst, MA. October, 2011. *Also served on Symposium Science Advisory Board and as Session Chair*.

Teaf, C.M. and B. J. Tuovila. 2011. Interpretation of Biological Data on Indoor Air Quality: Presence Doesn't Equate to Significance. Presented at 27th International Conference on Soils, Sediments & Water. Amherst, MA. October, 2011. *Also served on Symposium Science Advisory Board and as Session Chair*.

Teaf, C.M. and D.J. Covert. 2011. Risk Considerations Related to Environmental Arsenic Exposure: Drinking Water Ingestion versus Dietary Intake or Soil Exposure. Presented at the 27th Annual International Conference on Soils, Sediments and Water. Amherst, MA. October, 2011. *Also served on Symposium Science Advisory Board and as Session Chair*.

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Teaf, C.M. 2010. Health & Safety in the Workplace: The Good, the Bad and the Ugly. For Florida Department of Financial Services, Interagency Safety Academy. July, 2010.

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Teaf, C.M., J.B. Fisher, M.M. Garber, V.J. Harwood, S.N. Norris and R.L. Olsen. 2008. Field Applied Poultry Waste: Toxicology. Microbial Issues & Health. 24th Annual International Conference on Soils, Sediments and Water. October, 2008. Amherst, MA.

Teaf, C.M and M. Stephens. 2008. Dust in mining applications. Session III: Mining Impacts & Mitigation. Florida Aggregate Mining Education Forum - 2008. August, 2008.

Teaf, C.M. 2008. Safety in The Workplace: Recognition, Anticipation and Prevention. For the Florida Interagency Council on Safety and Loss. November, 2008.

Teaf, C.M. 2008. Safety on the Job: Dealing With Obvious and Not-so-Obvious Workplace Hazards. For FL Department of Financial Services, Div. of Risk Mgmt Interagency Advisory Council. July, 2008.

Personnel Health and Safety Refresher Training Course (8 hours). For Florida Department of Environmental Protection. Tallahassee, FL. April, 2008.

Weeks, N., Jones, D., Teaf, C.M., M. Lubozynski, and M. Petrovich. 2007. RBCA & Conditional Closure as a Brownfields Tool. 10th Florida Brownfield Conference & Exhibition. Nov, 2007. Orlando, FL.

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Teaf, C.M. and L. Gray. 2007. Principles, Terminology & Applications of Toxicology in a University Setting. Environmental Health & Safety Department, Florida State Univ, Tallahassee, FL. April, 2007

Teaf, C.M. 2006. Disinfection byproducts: Benefits & limitations of existing drinking water guidelines. U.S. Environmental Protection Agency Federal-State Toxicology and Risk Analysis (FSTRAC) "Safe & Clean Water" Meeting. December, 2006. Clearwater, FL.

Teaf, C.M. 2006. Arsenic bioavailability workshop: Physical and chemical characteristics of soils which influence decisions regarding arsenic bioavailability and health risks. EPRI Arsenic Work Group. December, 2006. Tampa, FL

Teaf, C.M. and P.H. Burress. 2006. Principles, Terminology & Applications of Toxicology in a University Setting. For Environmental Health & Safety Department, Florida State University, Tallahassee, FL. July, 2006.

Personnel Health and Safety Refresher Course (8 hours). For Florida Department of Environmental Protection. Tallahassee, FL. April, 2006.

Teaf, C.M., P.T. Medico, F.J. Bermudez, B.S. Clark. 2005. Case Study: Beneficial Use of RSM in Residential Applications. 15th Materials Reuse & Recycling Conference. June, 2005. Key West, FL.

Teaf, C.M. 2005. Chemicals in the Workplace: How a Toxicologist Analyzes Exposure. 10th Conference & CLE for the Workers Injury Law & Advocacy Group. April 2005. Washington, DC.

Personnel Health and Safety Refresher Course (8 hours). For Florida Department of Environmental Protection. Tallahassee, FL. April, 2005.

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Teaf, C.M. and R.M. Coleman. 2004. Where Does the Science Stand on Mold Issues? Technical Seminar for White & Case Law Firm and for Marsh, Inc. January, 2004. Miami, FL.

NATO Pilot Study Meeting on Human Health Issues and Tools for Disease Prevention in Central Asia. Almaty, Kazakhstan. November, 2003. (*Served as Session Moderator*).

Sixth International Symposium on Environmental Contamination in Central and Eastern Europe. Prague, Czech Republic. September, 2003. (*Session Moderator and Steering Committee Member*).

OSHA Refresher Course for University Health and Safety Activities (8 hours). For Florida State University. Tallahassee, Florida. June 11, 2003.

Statewide Video Conference on Chemical Terrorism. For Florida State University College of Medicine and Florida Department of Health. June 10, 2003.

Personnel Health and Safety Refresher Course (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. May 7, 2003.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. January 8, 2003.

NATO Advanced Research Workshop: Risk Assessment as a Tool for Environmental Decision-Making in Central Asia. Almaty, Kazakhstan. September, 2002. (*Served as Co-Director and Editor of Proceedings*).

Safety Concerns: Awareness for the Field Inspector. For Florida Department of Environmental Protection. St. Petersburg, Florida. August, 2002

Vulnerability of Municipal and Private Water Systems to Chemical Attack. Presented at World Health Organization Restricted Expert Consultation on Prevention and Management of Substance Terrorism Against Water Services. Copenhagen, Denmark. November, 2001.

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Safety Concerns: Awareness for the Field Inspector. For Florida Department of Environmental Protection. St. Petersburg, Florida. August, 2001

Planning Seminar on Introduction of the Rapid Environmental & Health Risk Assessment for the Lower Danube River. For WHO and Italian Ministry of Environment. Sofia, Bulgaria. January, 2001.

Evaluating and Communicating Health Risks. Holland & Knight Annual Environmental Seminar Series. Orlando, Florida. October, 2000.

Fifth International Symposium on Environmental Contamination in Central and Eastern Europe. Prague, Czech Republic. September, 2000. (*Session Moderator and Steering Committee Member*).

14th Annual Environmental Permitting School. Managing sites with chemical issues: Evaluation and presentation of risk information. Florida Chamber of Commerce. Marco Island, Florida. July, 2000.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Ft. Myers, Florida. August, 1999.

Toxicology and Risk Assessment: Using the Expert Witness. 1999 Annual Meeting, National Association of Legal Assistants. Tampa, FL. July, 1999.

Risk-Based Corrective Action at Miami International Airport. 1999 Hazardous Waste Management Conference. Miami, Florida. May, 1999.

Toxicology and Risk Considerations for Chlorinated Solvents. For Florida Department of Health & Rehabilitative Services. Wakulla Springs, Florida. May, 1999.

Fourth International Symposium on Environmental Contamination in Central and Eastern Europe. Warsaw, Poland. September, 1998. (*Session Moderator and Steering Committee Member*).

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Ft. Myers, Florida. July, 1998.

Risk Assessment Principles & Practice: Application to the Polish Environment. For Institute for Ecology of Industrial Areas and U.S. Department of Energy. Katowice, Poland. January, 1997.

Control of Reportable Diseases in Florida: A Public-Private Partnership. For Florida Department of Health & Rehabilitative Services. Tallahassee, Florida. October 24, 1996.

Third International Symposium on Environmental Contamination in Central and Eastern Europe. Warsaw, Poland. September, 1996. (*Session Moderator and Steering Committee Member*).

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. June 6, 1996.

Environmental Toxicology for Physicians *and* Medical History-taking in the Evaluation of Environmental or Occupational Disease. For Florida Department of Health & Rehabilitative Services. Sebring, Florida and Vero Beach, Florida. May 10 and May 15, 1996.

Control of Reportable Diseases in Florida: A Public-Private Partnership. For Florida Department of Health & Rehabilitative Services. Tallahassee, Florida. April 17, 1996.

RCRA Compliance Technical Assistance Training Courses. For Florida Department of Environmental Protection. Tallahassee, Florida (Eleven locations in Florida during period February to August, 1996).

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. April 2, 1996.

American Bar Association Section of Litigation, 8th Annual Environmental Litigation Midyear Meeting. Vail, Colorado. February 15-16, 1996.

12th Annual Environmental Permitting Course. Florida Chamber. Orlando, FL. January 17-18, 1996.

1995 Conference on State of Practice of Risk Assessment in Human Health and Environmental Decision Making. Tallahassee, FL. December 13-14, 1995. (*Session Moderator and Steering Committee Member*).

Risk Assessments, Audits & Other Compliance Management Tools. Environmental Compliance & Risk Management Seminar, Florida Chamber of Commerce. Tampa, FL. November, 1995.

Air Contamination in Central and Eastern Europe: What We Have Seen Since the Iron Curtain was Pulled Back. For Carolinas Air Pollution Control Association. Myrtle Beach, SC. October, 1995.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. September 27, 1995.

MGP'95 International Symposium and Trade Fair on the Cleanup of Manufactured Gas Plants. Prague, Czech Republic. September, 1995. (*Session Moderator and Steering Committee Member*).

Seafood Poisoning: Biological & Nonbiological Effects of Contaminated Fish and Shellfish from the Gulf of Mexico. For U.S. EPA, Florida Department of Health & Rehabilitative Services. Tallahassee, FL; Corpus Christi, TX; Lafayette, LA; Biloxi, MI; Daytona Beach, FL and Orange Beach, AL. March 26, May 22, July 15, August 3, August 18, October 13, October 18, November 11, 1994, June 6, 1995.

Required Personnel Health and Safety Refresher Course for Hazardous Waste Activities (8 hours). For Levine•Fricke. Tallahassee, Florida. August 14, 1995.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. May 18, 1995.

Worker Health and Safety Requirements. For U.S. Environmental Protection Agency RCRA Inspector Training Institute. Orlando, Florida. January 24-26, 1995.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Ft. Myers, Florida. January 12, 1995.

RCRA Personnel Health and Safety Training Course (40 hours). For Florida Department of Environmental Protection. Orlando, Florida. December 5-9, 1994.

Training Course in Principles of Toxicology, Risk Assessment and Risk Communication. Conducted for Florida Department of Health and Rehabilitative Services. Jacksonville, Florida. November, 1994.

Risk Assessments: Understanding Their Strengths and Weaknesses (*Session Co-Chair*). For the Florida Bar Association, Environmental and Land Use Law Committee. Tampa, Florida. October 10, 1994.

Training Course for RCRA Inspectors. For Florida Department of Environmental Protection. Tallahassee, Florida. October 4-6, 1994.

Second International Symposium on Environmental Contamination in Central and Eastern Europe. Budapest, Hungary. September 20-23, 1994. (*Session Moderator and Steering Committee Member*).

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Protection. Tallahassee, Florida. August 23, 1994.

Regulations, Environmental Considerations and Safety Aspects of Petroleum Sites under Chapter 17-770. For Florida Department of Environmental Protection. Tallahassee, Florida. June 7-8, 1994.

Toxicology & Risk Assessment Training Course. Conducted for Florida Department of Environmental Protection. Tallahassee, Florida. May 18-19, 1994.

Seminars for Physicians & Medical Personnel: Public Health Implications of Toxic Materials & Hazardous Waste Sites. For Florida Dept of Health and Rehabilitative Services, Agency for Toxic Substances and Disease Registry. Miami, Sarasota, Tallahassee, Florida. March 3, 11, 12, 25, 30, 1994.

Required Personnel Health and Safety Refresher Course for Hazardous Waste Activities (8 hours). For Levine•Fricke. Tallahassee, Florida. March 7, 1994.

Training Course in Principles of Toxicology, Risk Assessment and Risk Communication. Conducted for Florida Department of Health & Rehabilitative Services. Jacksonville, Florida. February 3-4, 1994.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. January 8, 1994.

RCRA Personnel Health and Safety Training Course (40 hours). For Florida Department of Environmental Regulation. Orlando, Florida. December 6-10, 1993.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. July 8, 1993.

Personnel Health and Safety Refresher Course for RCRA Activities (8 hours). For Florida Department of Environmental Regulation. Orlando, Florida. May 20, 1993.

Medical Seminars on Public Health Implications of Hazardous Waste Sites. For Florida Department of Health and Rehabilitative Services and Agency for Toxic Substances and Disease Registry. Pensacola, Ft. Lauderdale and Miami, Florida. March, April, May, November, 1993.

Training Course in Principles of Toxicology, Risk Assessment and Risk Communication. Conducted for Florida Department of Health and Rehabilitative Services. Ft. Myers, Florida. January 28-29, 1993.

Personnel Health and Safety Refresher Course for Hazardous Waste Activities (8 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. December 9, 1992.

RCRA Personnel Health and Safety Training Course (40 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. November 16-20, 1992.

Required Personnel Health and Safety Refresher Course for Hazardous Waste Activities (8 hours). For Levine•Fricke. Tallahassee, Florida. November 18, 1992.

First International Symposium on Environmental Contamination in Central and Eastern Europe. Budapest, Hungary. October 21-24, 1992. (*Session Moderator and Steering Committee Member*).

Training Course in Principles of Toxicology and Risk Assessment. For Florida Department of Health and Rehabilitative Services. Orlando, Florida. July 23-24, 1992.

RCRA Personnel Health and Safety Required Refresher Course (8 hours). For Florida Department of Environmental Regulation. Orlando and Tallahassee, Florida. May 29, June 23 and September 15, 1992.

Training Course in Principles of Toxicology and Risk Assessment. Conducted for Florida Department of Health and Rehabilitative Services. Tallahassee, Florida. June 18-19, 1992.

General Principles of Toxicology and Risk Assessment (3 Graduate Semester Hours). For Department of Biological Science, Florida State University. Tallahassee, Florida. January to April, 1992.

Medical Seminar on Community Public Health Implications of Hazardous Waste Sites. For Florida Department of Health and Rehabilitative Services and Agency for Toxic Substances and Disease Registry. Rockledge, Miami, and Orlando, Florida. April 10, April 24, May 28 and October 22, 1992.

Personnel Health & Safety Refresher Course for Hazardous Waste Activities (8 hours). For Florida Department of Environmental Regulation. Orlando, Tallahassee, FL. April, October, November, 1991.

RCRA Personnel Health and Safety Training Course (40 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. January 4-8 and September 16-20, 1991.

Physician Training Course on Public Health Implications of Environmental Toxicants. For Florida DOH and ATSDR. St. Petersburg and Orlando, Florida. April, September, 1991.

Supervisors Site Health and Safety Training Course for Hazardous Waste Activities (8 hours). For Levine•Fricke. Tallahassee, Florida. June 18, 1991.

Required Personnel Health and Safety Refresher Course for Hazardous Waste Activities (8 hours). For Levine•Fricke. Tallahassee, Florida. June 17, 1991.

Training Course on General Principles of Toxicology and Risk Assessment. Conducted for Florida Department of Health and Rehabilitative Services. Orlando, Florida. May 1-2 and May 21-22, 1991.

Training Course on Mixed Radioactive and Hazardous Waste. For Florida Department of Environmental Regulation. Tallahassee, Florida. October, 1990.

Physician Training Course on Public Health Implications of Environmental Toxicants. For Florida DOH and ATSDR. Tampa and Tallahassee, Florida. March 15 and July 24, 1990.

Mercury Contamination in Florida: Impacts and Solutions. Conducted by FSU Center for Biomedical & Toxicological Research, sponsored by 19 federal and state agencies. June 20-21, 1990.

Environmental Toxicology & Epidemiology: Practical Approach for Local Health Officials & Physicians. For National Association of County Health Officials, ATSDR, Florida DOH. Ft. Lauderdale, FL. July, 1990.

RCRA Personnel Health and Safety Training Course (40 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. June 4-8, 1990.

RCRA Personnel Health and Safety Required Refresher Course (8 hours). For Florida Department of Environmental Regulation. Tallahassee, Florida. May 31, 1990.

RCRA Personnel Health and Safety: Basic Training Course (40 hours). For Florida Department of Environmental Regulation. Orlando, Florida and Tallahassee, FL. April 24-28 and December 4-8, 1989.

Groundwater Investigations and Application to Assessment of Risks. For Florida Department of Environmental Regulation. Tallahassee, Florida. June 6-7, 1989.

Risk Assessment & Decision-Making Training. Conducted for Florida Department of Environmental Regulation and U.S. Environmental Protection Agency. Tallahassee, Florida. August 30-31, 1988.

Training Course on General Principles of Toxicology & Risk Assessment. For Florida Department of Health & Rehabilitative Services. Tallahassee, Florida. September/October, 1987. Orlando, Florida.

Hazardous Materials Training (Risk Assessment; Hazardous Materials Contingency Plans). Conducted for National Hazardous Materials Training Center, Little Rock, Arkansas. October 28-30, 1986.

Training Course on Toxicology: Hazardous Waste Field Activities. Conducted for the Florida Department of Environmental Regulation and the Florida Department of Health and Rehabilitative Services. Tallahassee, Florida. June 25-26, 1986 and Orlando, Florida. October 8-9, 1986.

Training Course on Emergency Response and Contingency Planning. Conducted for the U.S. Environmental Protection Agency. Atlanta, Georgia. March, 1985; March, 1986.

Training Course for the Holmes Regional Medical Center: Employee Toxic Substances Right-to-Know Program. Conducted for the Holmes Regional Medical Center. Melbourne, Florida. 1986.

Training Seminar on Florida Right-to-Know Law & Management of Hospital Hazardous Waste. Conducted for the Florida Hospital Association (FHA). November, 1985; August, 1986. Orlando, FL.

Hazardous Waste Disposal and Hazardous Substances Right-to-Know Regulations. Conducted for Florida Hospital Engineers Association. Orlando, Florida. April 4, 1986.

Second National Conference on Waste Exchange & Resource Reuse. Tallahassee, Florida. March, 1985.

Training Course on the OSHA Hazard Communication Standard. Orlando, Florida. February, 1985.

Symposium: Alternative Technologies for Waste Management. Tallahassee, FL. February, 1984.

Training Course on Toxicology and Risk Assessment. Conducted for the Florida Department of Health and Rehabilitative Services. Orlando, Florida. October 3-5, 1984.

Monitoring and Management of Hazardous Waste at RCRA Subtitle D Facilities. Conducted for U.S. EPA Office of Research & Development,. Tallahassee, Florida. October, 1984.

Symposium on EDB. Conducted for FL State University System. Tallahassee, FL. February, 1984.

Workshop on Monitoring Considerations in the Siting and Operation of Hazardous Waste Disposal Facilities in Temperate Zone Wet Environments. Conducted for the Office of Research and Development, U.S. Environmental Protection Agency. Tallahassee, Florida. October 4-5, 1983.

First National Conference on Waste Exchange and Resource Reuse. Tallahassee, Florida. March, 1983.

Hazardous Materials Contingency Planning Workshop. Conducted for Region IV, Environmental Emergencies Branch, U.S. Environmental Protection Agency. Atlanta, Georgia. March 26, 1981.

Workshop on Hazardous Waste Management for Educational Institutions. Conducted for the Florida Department of Education. Orlando, Florida. February 3-4, 1981.

Training Course on Management of Hazardous Waste and Hazardous Materials. Conducted for the Florida Department of Environmental Regulation. Orlando, Florida. January 14-15, 1981.

State Waste Exchange Workshop. For Florida Chamber of Commerce. Tallahassee, FL. December, 1980.

Hazardous Waste Management Seminar. Florida Engineering Society. Tampa, FL. November, 1980.

Hazardous Materials Incidents Workshop. For Leon County, Tallahassee, Florida. July, 1980.

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- ATSDR (Agency for Toxic Substances and Disease Registry). 2007b. ToxFAQs for Heptachlor and Heptachlor Epoxide. CAS # 76-44-8 and 1024-57-3. Available online at: www.atsdr.cdc.gov/toxfaqs/index.asp. August 2007. FPL-036.
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- FDEP (Florida Department of Environmental Protection). 2005. Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. February 2005. FPL-040.

FDEP (Florida Department of Environmental Protection). 2015. Chapter 62-550. Drinking Water Standards, Monitoring, and Reporting. July 7, 2015. FPL-053.

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FPL (FPL Central Laboratory). 2013a. Laboratory results for work order 13D0159. May 1, 2013. FPL-041.

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IRIS (Integrated Risk Information System). 2012. Tetrachloroethylene (Perchloroethylene); CASRN 127-18-4. February 10, 2012. Available online at: www.epa.gov/iris. FPL-051.

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