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SUPPLEMENTAL DIRECT TESTIMONY OF LINDA S. ERDREICH, PH.D.

SR. MANAGING SCIENTIST
EXPONENT, INC.

Subject: EMF: Epidemiology

INTRODUCTION

Q. Please state your name and business address.

A. My name is Linda S. Erdreich, Ph.D. My business address is 420 Lexington Avenue, Suite 408, New York, NY 10170.

Q. What is your occupation?

A. I am an epidemiologist with 25 years of experience in conducting and evaluating scientific research to identify factors that affect human health. I am a Senior Managing Scientist at Exponent, Inc., a research and consulting firm with a broad spectrum of expertise in science and technology. I work in the Health Group, which focuses primarily on the application of epidemiology methods to address a variety of topics in the health sciences. I have done a great deal of work evaluating potential biological and health impacts of electrical facilities, such as transmission lines, substations, and electrified railroad lines.

Q. Could you describe for us what epidemiology is?

A. Epidemiology is the science that studies the patterns of health and disease in human populations. Epidemiologists study the characteristics and exposures of people to determine what affects their health and the occurrence of disease. The objective of environmental epidemiology is to measure and evaluate the associations between exposures to environmental factors (e.g., air pollutants) and health outcomes (e.g. lung disease). Epidemiologic studies can help suggest links or associations between exposures and disease, and they provide direct evidence of possible effects in humans.

Q. Please briefly describe your prior work experience?

A. My curriculum vitae (HECO-ST-1100A) summarizes my prior work experience. Throughout my career I have been responsible for the assessment of the health

impacts of environmental agents, including chemicals and electric and magnetic fields (EMF).

I worked at the U.S. Environmental Protection Agency (EPA), where I conducted research to develop methods for setting exposure limits for chemicals to protect human health. These methods have been applied, for example, to the development of standards for water quality. The process of identifying potential effects and the exposure levels at which they occur is called health risk assessment. Health risk assessment is the process of determining, from scientific data, whether exposure to a specific factor in the environment is related to disease, and identifying what level of exposure is necessary to cause or affect the risk of disease. This process relies on a variety of data from toxicological (laboratory) and epidemiologic studies.

Q. Could you describe your educational background for us?

A. I received a B.A. in Biological Sciences and a M.Ed. in Science Education from Temple University, in Philadelphia, Pennsylvania. Subsequently I was awarded an M.S. in Biostatistics and Epidemiology (1977), and a Ph.D. in Epidemiology from the University of Oklahoma (1979).

Q. Are you a member of any professional organizations or associations?

A. I am a member of the Society for Epidemiologic Research, the Bioelectromagnetics Society, and the Institute of Electrical and Electronic Engineers. I am a Fellow of the American College of Epidemiology.

Q. What, if any, universities are you affiliated with?

A. I have been an adjunct associate professor in the Department of Environmental and Community Medicine at the Robert Wood Johnson Medical School in New Jersey since 1992. I held a similar position at the University of Cincinnati in Ohio

from 1982 to 1989.

Q. What experience have you had with health and biological issues related to power lines?

A. I have 25 years experience in analyzing and conducting research to assess the potential biological and health impacts of EMF. I am actively involved in advising various parties regarding health issues related to electrical facilities such as transmission lines, substations, and electrified railroad lines.

I have been asked to review research concerning transmission lines for federal agencies. I have also worked with the U.S. National Institute of Occupational Health and Safety (NIOSH), the Oak Ridge National Laboratories, the U.S. Department of Energy (USDOE), and the U.S. Federal Rail Administration (FRA) to review and evaluate health issues related to EMF from other sources. I have consulted with the Medical Services Division at the United Nations in New York.

I am a member of the Institute of Electrical and Electronics Engineers (IEEE), an international technical organization, and I participate in IEEE committees that develop exposure limits, or standards. One of these committees develops exposure limits, or standards, for EMF in the low frequency range 0 to 3000 Hz, the range that includes fields from power lines and other electrical sources. I have published papers in scientific journals, and have prepared book chapters and technical reports. I routinely serve as a reviewer for scientific journals that specialize in epidemiology and public health research, and others that specialize in electromagnetic energy.

Q. Have you provided expert testimony in any other proceedings? If so, what were they?

A. Because of my background and experience, I have been asked to provide information on EMF in a number of different forums, including state Public Service Commissions or similar organizations. I have testified in legal proceedings.

Q. Were you qualified as an expert in those proceedings?

A. Yes, I was.

METHODS FOR EVALUATING SCIENTIFIC RESEARCH

Q. How do scientists determine whether an environmental exposure poses a health risk?

A. Scientists determine whether an environmental exposure poses a health risk based on a systematic assessment of all relevant scientific research, which includes epidemiologic and laboratory studies of humans, laboratory studies in animals (*in vivo*), and laboratory studies in cells and tissues (*in vitro*). This process is designed to be unbiased and comprehensive to ensure that more weight is given to those studies of better quality, and that studies with a given result are not selected from those available to favor a preconceived idea of effect.

Data from both epidemiology and laboratory studies are considered together for several reasons. Epidemiology studies and laboratory studies have strengths as well as limitations, but taken together, the strengths and limitations balance one another. For example, epidemiological studies include people in their natural environment, which is an advantage. However, humans vary in their diet, behaviors and habits, exposures and genetics, all of which may relate to their risk of disease. Additionally, the exposure being studied is not under the control of the investigator. In the laboratory, animals, or human volunteers are selected for

similar characteristics and are exposed to precisely defined and measured quantities. However, laboratory animals are not the same as people, and laboratory conditions do not always reflect real world conditions. When we consider these studies together, we get more information than if we relied on only one type of study.

Critical evaluation of this information is important because no one study is perfect; each study has its strengths and weaknesses. For this reason, repeating a laboratory research study is important because a reproducible result increases confidence that the observation is correct and not the result of an unforeseen error.

This approach for assessing potential risk to human health from environmental exposures is described as a *weight-of-evidence* approach. Scientists, scientific organizations, and regulatory agencies worldwide use it. These organizations include the International Agency for Research on Cancer (IARC), which routinely evaluates substances such as drugs, chemicals, and occupational exposures that may cause cancer (e.g., IARC, 2002), and the EPA (USEPA, 2003).

Q. What scientific information is available about EMF and potential effects on health?

A. The published scientific information on EMF and health includes hundreds of epidemiological studies of people whose exposure was assessed at their place of work or at their residence, and laboratory data collected on cells, tissues, or animals. The research also includes studies of people exposed under controlled conditions for short periods of time. Descriptions of the research can be found in peer-reviewed scientific journals and in technical reports.

Q. Do scientists follow special procedures to critically evaluate epidemiology

studies?

A. Yes, critical evaluation of epidemiologic studies is important to determine whether a statistical association is an indicator of cause and effect. *Association* means that two things tend to occur together, although an association does not prove by itself that one is the cause of the other. One example of a strong association is that of a rooster crowing and the sun rising. Although they always occur together, one would not conclude that the rooster causes the sun to rise. Similarly, the increase in price of a subway ride in New York has been correlated with an increase in the price of pizza, but again, increases may occur in the same year, but there is no reason to conclude that the price of transportation causes an increase in the price of pizza, or vice versa. It is possible that the state of the economy is the underlying cause of each of these increases.

A major part of analyzing epidemiology studies is to determine whether intervening (confounding) variables, chance, or bias, has influenced the results (IARC, 2002). In the example about the subway fare and pizza, the state of the economy may be the confounding factor. In scientific terms, bias does not necessarily refer to prejudice or other subjective factors; rather, it refers to the deviation of results or inferences from the truth and also refers to any process leading to such deviation (Last, 2001). Any approach in the collection, analysis, interpretation, publication, or review of data that can lead to conclusions that are systematically different from the truth is a source of bias.

Epidemiologists also typically refer to a set of criteria to guide them in determining whether the associations reported in epidemiologic studies support a cause and effect relationship between exposure and disease. These are often referred to as the Hill criteria, after the British physician who originally proposed

them (Hill, 1965).

Q. Can you explain how epidemiologists use these criteria to determine whether an association indicates causality?

A. Yes. These criteria are not answered with a simple "yes" or "no", rather, they serve as guidance for weighing the evidence to reach a decision about cause and effect. The more firmly these criteria are met by the data, the more convincing the evidence.

The observed statistical associations are more likely to indicate cause and effect, as follows: (1) Strength: the stronger the associations between the disease and the agent in question the more persuasive the evidence; (2) Consistency: consistent results across different study populations are more convincing than isolated observations; (3) Dose-response: an increase in disease with an increase in the level of exposure, that is, a dose-response relationship, is more likely to be observed if an association is causal; (4) Biological plausibility: epidemiologic results are much more convincing if they are supported by the biological evidence, and if there is a demonstrated mechanism to explain the effect; (5) Specificity: a statistical association is more convincing if the specific exposure is associated with a specific disease or condition; (6) Temporality: the data must provide evidence of correct temporality, that is, the exposure to the purported cause must be documented to have occurred prior to the observed effect, with sufficient time for any induction period related to the disease (e.g., cancer) and; (7) Coherence: a causal association is a more likely explanation of the data if it is compatible with other scientific evidence.

These criteria are included in epidemiology textbooks, and are presented in the *Reference Manual on Scientific Evidence* as factors to consider in making a

judgment about causation (Green et al, 2000).

EVALUATION OF SCIENTIFIC RESEARCH REGARDING EMF AND HEALTH

Q. What do the epidemiological studies indicate about residential or community exposures to EMF and cancer?

A. Some early epidemiology studies reported that a few more of the cases (children who had cancer) had lived closer to certain types of power lines, or were exposed to higher estimated magnetic fields than the controls (children in the study without cancer) (Wertheimer et al, 1979; Savitz et al, 1988; Feychting and Ahlbom, 1993). This statistical association between power lines and disease was not considered an indication of cause and effect because of limitations of these specific studies, such as small study size or imprecise measures of exposure. To clarify the meaning of these earlier studies, larger and better studies were undertaken. These larger studies have not shown convincing, consistent associations between power lines and any specific type of cancer (e.g., Linet et al, 1997; Preston Martin et al, 1996a, 1996b; McBride et al, 1999; Kleinerman et al, 2000; UK Childhood Study investigators, 1999, 2000a,b, 2002). However, because of the small number of children in these studies with high exposures, the possibility of an association between higher magnetic field levels and childhood leukemia cannot be excluded.

In 2000, researchers reanalyzed data from all the previous epidemiology studies of magnetic fields and childhood leukemia that assessed exposure to magnetic fields using 24-hour measurements or calculations based on the characteristics of the power lines and current load (Ahlbom et al, 2000; Greenland et al, 2000). In each of these analyses, the researchers pooled data on individuals from each of the studies, creating a study with a much larger number of subjects

and therefore greater statistical power to detect an effect if there were one, than any single study.

One of the main results of these analyses was that pooling these data did not suggest an association between childhood leukemia and magnetic fields for long-term average exposures below 3 milligauss (mG). However, a weak statistical association with leukemia was found for long-term average exposures greater than 3-4 mG. This statistical finding must be evaluated carefully, according to general principles and criteria described above. First, in these studies, few children, if any, had exposures that averaged above 3 mG. Thus, there is considerable statistical uncertainty, making it more difficult to rule out the role of chance. Second, pooling of the data from individual studies does not address their individual limitations. For example, in some studies, sources of potential bias could not be ruled out.

Q. What do laboratory studies indicate about the possible role of EMF in cancer?

A. Studies in which laboratory animals receive high exposures provide an important basis for evaluating the safety of chemicals and medicine, and of EMF as well. The most informative laboratory research for assessing cancer and health risks are studies in which laboratory animals, usually mammals such as rats or mice, have received high exposure over a time period up to the average life span of the species. At the end of the exposure period, the animals' organs are carefully examined for any evidence of cancer.

In several recent studies, groups of rats or mice were exposed to magnetic fields for a time equivalent to their normal lifespan. In these studies, neither overall cancer occurrence nor the occurrence of specific types of cancer such as brain cancer, breast cancer or leukemia were higher in animals exposed to

magnetic fields than in unexposed, control animals, even at the highest exposure levels (e.g., Yasui et al, 1997; Babbitt et al, 1998; McCormick et al, 1999).

Studies of tumor formation and the advancement of tumor development (tumor promotion) in animals have not shown that magnetic fields promote the growth of cancer in general, or breast or brain cancer in particular (e.g., DiGiovanni et al, 1999; Boorman et al, 1999a, b; Anderson et al, 1999; Mandeville et al, 2000), although there have been suggestive findings from one laboratory (discussed in Anderson et al, 2000). In a study of a different design, Morris et al (1999) used an animal model for progression of leukemia that involves transplanting leukemia cells into young rats prior to exposure. In this study, exposure to magnetic fields did not alter or increase the speed in which the cells developed into leukemia.

My review of the combined animal bioassay results and other laboratory research does not find persuasive evidence that magnetic fields cause, enhance, or promote the development of leukemia, lymphoma, or mammary cancer (see also Boorman et al, 2000a, b).

Q. What does the scientific research show about exposure to EMF and its effects on pregnancy and miscarriage?

A. There are many studies designed to examine effects on reproduction. As for any other potential effect on health, it is important to consider studies in the laboratory, particularly on mammals, as well as epidemiology studies of people.

Laboratory studies of mammals (rats, mice) have exposed the animals to 60-Hz electric or magnetic fields before or during pregnancy, and in some studies exposure occurred over several generations. The animals in the litters were examined externally and internally, and no changes were found that would

indicate an increase in miscarriage, birth defects, or loss of fertility. Exposed and unexposed litters did not differ in the amount of fetal loss and the number and type of birth defects, indicating no adverse reproductive effect of magnetic fields (e.g., Rommerein et al, 1990; Sienkiewicz et al, 1994; Ryan et al, 1999; Ryan et al, 2000; Huuskonen et al, 2001).

Several epidemiology studies have examined effects of exposures to magnetic fields on pregnancy, including miscarriages (spontaneous abortion). These studies reported no association with birth weight or fetal growth retardation after exposure to sources of relatively strong magnetic fields, such as electric blankets, or sources of typically weaker magnetic fields such as power lines (Bracken et al, 1995; Belanger et al, 1998; Lee et al, 2000). Two recent studies of EMF and miscarriage reported a positive association between miscarriage and exposure to high maximum, or instantaneous, peak magnetic fields from all sources based on a 24-hour measurement period (Li et al., 2002; Lee et al., 2002). These high peak field levels are typical of electric appliances, devices with electric motors and electric transit. However, no reliable associations were found with higher *average* magnetic field exposures during the day, the typical way of assessing exposure.

There are several possible issues to be considered in assessing whether these statistical associations with the maximum magnetic field exposure during the day are possibly causal in nature. First, the studies include possible biases. For example, each of the studies had a low response rate, which means that the study groups may not be comparable because those who participated in the studies may have differed from those who declined (selection bias). Second, these studies found no reliable association with higher daily average exposure, that is, the

average of all the measurements recorded throughout the day. Third, despite years of research, there is no biological basis to indicate that EMF increases the risk of miscarriage.

EVALUATIONS OF EMF RESEARCH BY NATIONAL AND INTERNATIONAL SCIENTIFIC ORGANIZATIONS

Q. What conclusions about EMF have been reached by scientific and regulatory organizations in the United States?

A. Scientists have been convened by several organizations to work together to review the scientific information on EMF. These panels included representatives from diverse organizations, who had expertise in several different scientific disciplines including the biological sciences (toxicology, genetics, epidemiology, cancer biology) and the physical sciences (physics or engineering).

In 1992, Congress mandated an EMF research program, which was managed by National Institute of Environmental Health Sciences (NIEHS). In 1998, the NIEHS convened a Working Group to evaluate the results of this research program and other EMF research. They concluded that the epidemiologic data was limited, but they categorized EMF as possibly carcinogenic. Using the methods routinely applied by of the National Toxicology Program (NTP) of the National Institutes of Health, the NIEHS concluded that EMF exposure would not be listed in the NTP Report on Carcinogens as a “known human carcinogen” or as “reasonably anticipated to be a human carcinogen.”

The NIEHS prepared a report to the US Congress and concluded that the probability that EMF is a health hazard is relatively small and evidence is insufficient to warrant aggressive regulatory actions (NIEHS, 1999). They suggested that “the power industry continue its current practice of siting power

lines to reduce exposures and continue to explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards" (p. 38).

Q. Has research subsequent to this review modified these findings?

A. The epidemiological and laboratory data published after the NIEHS report was completed in 1998 have provided additional evidence that EMF does not contribute to childhood cancer. For example, a large (more than 1,000 cases) and well-designed epidemiologic study of childhood leukemia was conducted in England by the United Kingdom Childhood Cancer Study investigators (UKCCS, 1999). These researchers reported no increased risk of leukemia in those children with average annual exposures to EMF from 2 mG up to 4 mG in the home and school. No statistically significant increase was found for children whose exposure was above 4 mG, that is, a small increase was reported but chance could not be excluded as an explanation. Investigators at the National Cancer Institute reported no association between childhood leukemia and EMF in their study (Linet et al, 1997), and a reanalysis using a different measure of exposure also found no evidence of cancer risk (Kleinerman et al, 2000). In addition, the majority of studies of breast cancer have not supported an association with residential EMF (Gammon et al, 1998; Forssén et al, 2000; Kabat et al, 2003; London et al, 2003; Schoenfeld et al, 2003).

Laboratory studies published after the NIEHS report, some of which were part of the research program and available for review by the NIEHS, provide evidence for a lack of carcinogenicity, or provide no basis to conclude that EMF affects the development or promotion of cancer (e.g., Babbitt et al, 1998; Anderson et al, 1999; Boorman et al, 1999; McCormick et al, 1999; Morris et al,

1999; Mandeville, 2000).

Q. Have other organizations outside of the United States sponsored independent reviews of EMF research by multidisciplinary groups of scientists?

A. Yes, several organizations have conducted or sponsored comprehensive reviews. The International Agency for Research on Cancer (IARC), the International Commission on Nonionizing Radiation Protection (ICNIRP), the Health Council of the Netherlands (HCN), the National Radiological Protection Board of Great Britain (NRPB) have all convened large groups of independent scientists with different expertise (epidemiologists, toxicologists, biologists, neurobiologists, physicists, etc.) to review the body of literature surrounding EMF and health. Each organization has produced a report that is available to the public.

Reviews of the scientific research regarding EMF and health by the HCN were published in 2000 and updated in 2001 and 2004. ICNIRP published its review in 2003. The NRPB published reviews in 2001 and 2004, which included comprehensive discussions of the individual research studies.

Q. What overall conclusion did the IARC Working Group reach regarding childhood leukemia?

A. IARC reviewers evaluated the animal data and concluded that they were "inadequate" to support a risk for cancer. The scientists stated that the EMF data does not merit the category "carcinogenic to humans" or the category "probably carcinogenic to humans," nor did they find that "the agent is probably not carcinogenic to humans." Many hypotheses have been suggested to explain possible carcinogenic effects of electric or magnetic fields; however, no scientific explanation for carcinogenicity of these fields has been established (IARC, 2002).

The Working Group concluded that the epidemiologic studies do not

provide support for an association between childhood leukemia and residential magnetic fields at intensities less than 4 mG. Overall, magnetic fields were evaluated as "possibly carcinogenic to humans" (Group 2B), based on the statistical association of higher-level residential magnetic fields with childhood leukemia. Other agents and mixtures have been classified as 2B as well, including coffee, pickled vegetables, and gasoline engine exhaust.

In the rating system used by IARC, the recognition of an association between exposure and cancer in epidemiology studies is considered "limited evidence" of carcinogenicity. A rating of "limited evidence" for epidemiology studies, even without any evidence from laboratory studies that an exposure might pose a cancer risk, requires that the exposure be categorized as a "possible carcinogen," even though chance, bias and confounding cannot be ruled out with reasonable confidence (IARC, 2002).

Q. Why did the IARC Working Group not regard the association between magnetic fields and childhood leukemia as reflecting a causal relationship?

A. They did not regard the association as causal because there was insufficient evidence from epidemiology studies that magnetic fields caused cancer in humans, insufficient evidence that magnetic fields caused cancer in laboratory studies of animals, and no evidence for a mechanism to lead to cancer.

Q. What are the conclusions of the other review groups, and how do they compare with IARC?

A. The assessments by the NIEHS, IARC, ICNIRP, NRPB, and HCN agree that there is little evidence that EMF is associated with adverse health effects, including most forms of adult and childhood cancer, heart disease, Alzheimer's disease, depression, and reproductive effects. However, all of the assessments concluded

that epidemiology studies in total suggest a possible association between magnetic fields at higher exposure levels (annual average greater than 4 mG) and childhood leukemia. All agree that the experimental laboratory data do not support a causal link between EMF and any adverse health effect, including leukemia, and have not concluded that EMF is, in fact, the cause of any disease. These organizations have not recommended exposure limits or required measures to reduce exposures since they have not concluded that a causal relationship between EMF and adverse health effects exists.

Q. Are there other reviews or summaries published about EMF and health?

A. Yes, other organizations have provided perspectives on EMF and health. These include a report from the California EMF Program and a more recent summary from the NIEHS.

In response to a request from the California Public Utilities Commission, three scientists from the California EMF program (two epidemiologists and a physicist) reviewed the scientific research regarding EMF and health (Neutra et al, 2002). The scientists agree that EMF is not a universal carcinogen. They evaluated data regarding 13 health conditions and concluded that the epidemiologic data provided little support for an association of EMF with nine of the conditions. For the rest, they expressed the belief "that EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's disease, and miscarriage." Their median "confidence ratings" for these conditions, however, were not high enough to indicate any strong certainty or "high probability" that EMF was a cause of these conditions.

At the time the conclusions of the California EMF Program became available, the NIEHS published a brochure on questions and answers on EMF and

health (NIEHS, 2002). The status of EMF and health is summarized by NIEHS as:

> Over the past 25 years, research has addressed the question of whether exposure to power-frequency EMF might adversely affect human health. For most health outcomes, there is no evidence that EMF exposures have adverse effects. There is some evidence from epidemiology studies that exposure to power-frequency EMF is associated with an increased risk for childhood leukemia. This association is difficult to interpret in the absence of reproducible laboratory evidence or a scientific explanation that links magnetic fields with childhood leukemia (p. 57).

The NIEHS also noted that:

> At the current time in the United States, there are no federal standards for occupational or residential exposure to 60-Hz EMF (p. 57).

MAGNETIC FIELDS ASSOCIATED WITH THE EAST OAHU TRANSMISSION PROJECT

Q. What else have you considered to assess the health impact of this project?

A. I have considered the general description of the project and available information on the assessment of EMF levels from the proposed underground power lines. This included a description of the background and alternatives in the testimony of HECO's project manager Kerstan J. Wong, and the testimony of HECO's William Bonnet regarding EMF policy issues. I reviewed the magnetic field evaluation and measurements for the proposed power lines prepared by Enertech Consultants of Santa Clara, Inc. ("Enertech"), and the testimony of Michael Silva of Enertech.

Q. Did you review the magnetic field levels expected to occur with the proposed project?

A. Yes. Enertech's Magnetic Field Evaluation projected the magnetic field levels that would be associated with both the existing and the proposed configurations for the load forecasted for 2009. This evaluation indicated that some increases would occur with the proposed configuration in some of the route segments. I also reviewed the levels that were projected to occur at public institutions near the proposed project, and the levels measured at eleven different areas in Honolulu.

Q. Based on your review, how would you characterize the magnetic field levels related to the proposed line?

A. These levels are within the range of magnetic field levels found at numerous locations in the local environment. The line locations are mainly in the street, and the forecasted increases occur predominantly in the street and sidewalk, and so would be mostly a source of brief intermittent exposure to the population (Enertech, 2004). Magnetic field levels decrease with distance from the source, and the projected magnetic field levels beyond the sidewalks for any of these segments are well within the range of levels commonly encountered in the local area and in other communities.

The magnetic field levels projected for six selected public institutions within 100 feet of the proposed route indicated either no influence of the fields or a minimal increase. For example, the projected magnetic field under normal operating conditions is less than 4 mG at a corner of the Lunalilo Elementary School, which represents no increase over the existing configuration.

Q. How do the projected magnetic fields calculated by Enertech, or the magnetic fields measured in the local area, relate to personal magnetic field exposure?

A. A magnetic field value calculated or measured at a particular location at an instant in time is <u>not</u> a measure of human exposure. What we mean by exposure are the

magnetic field levels encountered by a person as averaged over a specific period of time. For example, it takes about a second to measure a magnetic field. Over that second, the exposure and the measurement would be the same, i.e., the value displayed on the meter. However, if I took readings every second over an entire year wherever I went, the average of those 31,536,000 measurements would represent my average annual exposure to magnetic fields.

An individual's exposure to magnetic fields reflects the contribution from all of the magnetic field sources encountered in all the locations where she spends time. Because people typically spend most of their time at home, the sources there are frequently the major determinant of their time averaged exposures.

Misunderstandings arise however, because both measured (or projected) field values and exposures are both expressed in units of milligauss, though they represent quite different concepts.

Q. What do the projected magnetic field values at the curb given in Enertech's 2004 report represent?

A. They are calculated values at a particular location and cannot be meaningfully compared to estimates of long-term exposure to magnetic fields referenced in epidemiologic studies.

Q. Why are estimates of long-term exposure to magnetic fields of interest?

A. They are of interest because the strongest data supporting the existence of any health effect from magnetic fields are reports of associations between estimates of magnetic field exposure and childhood leukemia. This association is based primarily upon two published statistical evaluations of the epidemiology studies of childhood leukemia and long-term exposures (Greenland et al 2000; Ahlbom et al, 2000). Note that 4 mG refers to an estimated long-term average exposure. The

goal of these epidemiology studies has been to estimate the average exposure of an individual over a long time, not the fluctuating level at any single spot, whether it is in the playground, a school, or a place in the home.

The reason for our focus on long-term exposures is based upon the knowledge that chemicals and agents in the environment that are known to cause cancer, e.g., tobacco smoke, alcohol, and sunlight, require repeated exposures at elevated levels over long periods of time. Therefore, scientists do not expect an association with these diseases to exist for persons with infrequent or very low-level exposures to these agents. The same rationale has been applied by epidemiologists in the study of magnetic fields; while opportunities for short-term exposures to magnetic fields in excess of a few mG or even 100 mG abound in our environment, the exposure of interest is a person's long-term average exposure.

Thus, a calculated or measured magnetic field greater than 4 mG in a playground, school or even a small area of a residence would not necessarily indicate that a child would have an average exposure greater than 4 mG.

Q. Based on your review of the scientific data, what do you conclude regarding EMF and public health?

A. I conclude that EMF exposures at typical environmental levels are not harmful to people, whether they are exposed from transmission lines, other power line sources, or other sources in homes. Electric and magnetic fields can be harmful at very high levels, but not at the levels associated with power lines. With certain electric appliances, the user is exposed to magnetic fields that can be tens to hundreds of times higher than transmission line fields. Electric fields from power lines are generally well below levels that would cause harmful effects, and must be low in order to meet electrical safety standards.

Q. Based on your review, will the EMF levels expected to occur with the proposed line have an unreasonable adverse effect on public health, safety, and welfare?

A. No. The weight of the evidence that I have reviewed does not support a conclusion that exposure to EMF at the levels associated with the proposed project would have adverse effects on human health, compromise normal function, or cause cancer.

SUMMARY

Q. Could you briefly summarize the basis for your conclusions?

A. This conclusion is based on my knowledge of the relevant scientific literature, the results of expert scientific panels that have examined epidemiologic and laboratory research on 60-Hz electric and/or magnetic fields and health, and the field levels anticipated from the operation of this transmission line. The *weight-of-evidence* analysis I conducted follows procedures used by scientists, scientific organizations, and regulatory agencies worldwide. I evaluated each of the individual epidemiologic studies of magnetic fields and health in order to assess the strengths and limitations of each, and assign more weight to those with better design. I assessed the epidemiologic studies collectively, and considered the results of the controlled laboratory research studies in cells and in animals, including those of long-term exposure of laboratory animals to magnetic fields. The Hill Criteria for causality guided my review. I considered that the epidemiology studies reported only weak, inconsistent associations, and there is no convincing evidence of a dose-response relationship. The laboratory data do not provide sufficient evidence that the association is biologically plausible.

There is insufficient evidence to conclude that there is a causal

relationship between magnetic field exposure and childhood leukemia (or other cancer), based on these data, taking into account the fact that there is neither a plausible mechanism nor a biologic basis to support such an association.

Q. Are the references cited in your testimony listed in HECO-ST-1101A.

A. Yes.

Q. Does this conclude your testimony?

A. Yes, it does.