THE STATE OF NEW HAMPSHIRE

BEFORE THE

SITE EVALUATION COMMITTEE

DOCKET NO. 2015-06

PRE-FILED DIRECT TESTIMONY OF DR. WILLIAM H. BAILEY

IN SUPPORT OF THE
APPLICATION OF NORTHERN PASS TRANSMISSION LLC
AND PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
D/B/A EVERSOURCE ENERGY
FOR A CERTIFICATE OF SITE AND FACILITY TO CONSTRUCT A NEW HIGH VOLTAGE TRANSMISSION LINE AND RELATED FACILITIES IN NEW HAMPSHIRE

October 16, 2015

Qualifications and Purpose of Testimony

Q. Please state your name and business address.

A. My name is William H. Bailey. I am employed by Exponent, Inc. (Exponent), a scientific and engineering firm, in an office located in the Maryland Science and Technology Center at 17000 Science Drive, Suite 200, Bowie, Maryland, 20715.

Q. What is your position at Exponent?

A. I am a Principal Scientist in the Center for Occupational and Environmental Health Risk Assessment in Exponent's Health Sciences Practice.

Q. Please describe your current responsibilities.

A. My practice specializes in the health sciences and, more specifically, in human exposure and risk assessment. My work involves reviewing, analyzing, and conducting health research. Much of my work relates to the exposures and potential biological, environmental, and health effects associated with electrical facilities, such as transmission lines and substations, and with electrified railroad lines, including the possible effects of electric and magnetic fields ("EMF"). In the course of this work, I work with and supervise professionals in diverse health, engineering, and environmental practices, mentor junior scientists and engineers, and direct scientific research and data collection.

Q. Please summarize your education and academic research and teaching experience.

A. I earned a Ph.D. in neuropsychology from the City University of New York in 1975. My education includes a BA from Dartmouth College, awarded in 1966, and an MBA from the University of Chicago, awarded in 1969. With the support of the U.S. National Institutes of Health I received two years of additional postdoctoral training in neurochemistry at The Rockefeller University in New York City. After this training I conducted research for seven years as an Assistant Professor at The Rockefeller University in the field of neurochemistry. Since 1986, I have been a visiting research scientist at the Cornell University Weill Medical College. I also have been a visiting lecturer at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. From 1983 through 1987, I was head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research.

Q. Are you a member of any professional organizations?

A. I am a member of the Rockefeller University Chapter of Sigma XI, a national scientific honor society; the Health Physics Society; the International Committee on Electromagnetic Safety, Subcommittees 3 and 4 – Safety Levels with Respect to Human Exposure to Fields; the Bioelectromagnetics Society; the Engineering in Medicine and Biology Society of the Institute of Electrical and Electronics Engineers ("IEEE"); the Conseil International des Grands Réseaux Électriques; the American Association for the Advancement of Science; the New York Academy of Sciences; the Society for Neuroscience; the Air & Waste Management Association; the Society for Risk Analysis; and the International Society for Exposure Analysis.

Q. Have you served as a reviewer and scientific advisor on health-related issues for state and federal agencies or scientific organizations?

A. Yes. I have reviewed research for the National Institutes of Health, the National Science Foundation, and other government agencies. Specifically regarding transmission lines, I served on a Scientific Advisory Panel convened by the Minnesota Environmental Quality Board to review the health and safety aspects of a high-voltage transmission line. In addition, I served as a consultant on transmission line health and safety issues to the Vermont Department of Public Service, the New York State Department of Environmental Conservation, and the staffs of the Maryland Public Service Commission and the Maryland Department of Natural Resources.

I have worked with the National Institute of Occupational Safety and Health, the Oak Ridge National Laboratories, the U.S. Department of Energy, and the Federal Railroad Administration to review and evaluate health issues related to EMF from other sources. I also assisted the U.S. EMF Research and Policy Information Dissemination ("RAPID") program to evaluate biological and exposure research as part of its overall risk assessment process.

I worked with scientists from 10 countries to evaluate possible hazards from exposures to static and extremely low frequency ("ELF") EMF[1] for the International Agency for Research in Cancer ("IARC"), a division of the World Health Organization ("WHO") located in Lyon, France. I also was an invited participant in the workshop convened by the International

[1] ELF EMF also is referred to as power frequency EMF or simply EMF.

Committee on Non-Ionizing Radiation Protection ("ICNIRP") to update guidelines for human exposures to alternating current ("AC") EMF. I have reviewed ICNIRP's draft guidelines for direct current ("DC") and AC magnetic fields as well.

Most recently, I have served as an advisor to government agencies in Canada and the Netherlands on topics relating to scientific research on EMF health and safety.

Q. Have you published or presented your research in bioelectromagnetics and other areas to the scientific community?

A. I have published or presented more than 50 scientific papers on this and related subjects. These publications and presentations are listed in my *curriculum vitae*, attached as Attachment A.

Q. What is the purpose of your direct testimony?

A. The purpose of my testimony is to summarize my human health and safety assessment of the EMF associated with the operation of the Northern Pass Transmission Project ("Northern Pass" or the "Project") proposed by Northern Pass Transmission, LLC ("NPT"), and to assess whether EMF associated with the Project would result in an unreasonable adverse effect on public health and safety.

Q. What is the scope of your assessment?

A. I evaluated the potential effects of the proposed Northern Pass lines on humans, livestock, wildlife, and plants. My assessment included an analysis of the entire Project, including the ±320-kilovolt (kV) DC transmission line from the Québec/New Hampshire border to the DC/AC converter terminal in Franklin, New Hampshire; and (2) the 345-kV AC transmission line between the Franklin converter terminal and the substation in Deerfield, New Hampshire, and the existing 115-kV AC transmission lines or lower voltage distribution lines along the Project route. My evaluation focused on the magnetic fields, electric fields, and electric charges in the air (space charge) associated with the operation of these facilities. The calculated values of their levels and distribution around the Project are provided in the pre-filed testimony of Dr. Gary Johnson and the technical report he is sponsoring. See Appendix #38.

My evaluation of these calculated exposures and the current scientific knowledge about their potential to affect human health and the biological environment is contained in Appendix 37 of the application and is summarized below.

Methods for Assessment

Q. What do scientists know about these exposures?

A. First, we know a great deal about these exposures because they are found everywhere in our everyday environment. Static (i.e., DC) fields and charges have always been a part of our natural environment. AC fields, like those associated with portions of the Project, have been a part of our environment since the early 20th century when the use of electricity came into common use.

Second, we also know how fields and electric charges interact with objects in the environment and this knowledge is a key component of assessing potential effects.

Finally, because research on the potential effects of electrical exposures on humans, animals, and plants has been conducted for over a century, there is a wealth of knowledge about the potential biological and health effects of these exposures.

Q. What criteria did you use to assess potential Project effects?

A. My assessment of the potential effects of the Project on public health and safety is based on current scientific knowledge as summarized in published research, scientific reviews by national and international agencies, and specifically the guidelines and standards established by these agencies. These guidelines and standards serve as criteria for the assessment of AC and static electric fields, as well as AC and static magnetic fields. No such established criterion for the assessment of space charge was identified.

Q. What were the steps in your assessment?

A. My assessment took into account multiple sources of information. First, I reviewed previous assessments of the scientific research conducted by scientists for both scientific and government agencies, and the relevant standards and guidelines for exposure. Next, I compared the effect of the Project on the potential exposure of adjacent populations and the environment as compared to their background exposure levels derived from other sources. Finally, I searched and reviewed the scientific literature to identify new relevant research that might shed light on potential mechanisms of interaction with organisms and effects on their biology, health, and behavior to assess the cumulative weight of the evidence, as is customarily done for health risk assessments.

Summary of Assessment Relevant to Proposed AC Transmission Lines

Q. How do AC electric fields interact with organisms?

A. While an AC electric field can oscillate charges on the surface of the body, the inside of the body is significantly shielded from external AC electric fields because of the high conductivity of the tissues. Thus, the electric field inside the body is roughly 1,000,000 times weaker than an external electric field.

Q. How do AC magnetic fields interact with organisms?

A. AC magnetic fields are not perturbed by the presence of a conducting body; therefore, the field inside of the body is the same as on the outside. The presence of AC magnetic fields can induce weak electric fields and currents in the body.

Q. What are the potential effects of surface charges and internal electric fields?

A. Charges accumulated on the body surface may discharge to lower potential, grounded objects and may be perceived as micro-shocks (similar in nature to carpet shocks). Internal electric fields and current densities, at high levels, may result in stimulation of excitable tissues, such as nerve and muscle. These effects may occur at very high field levels and are immediate and reversible.

Q. Are there any standards or guidelines for AC electric and magnetic fields?

A. There are no federal standards in the United States or Canada for 60-Hertz (Hz) EMF exposures. There is no guideline limiting levels of EMF from transmission lines in New Hampshire.

There are guidelines, however, developed by international scientific agencies to protect the public and workers from established biological effects of these fields. There are two internationally recognized agencies that develop guidelines for these fields: ICNIRP and the International Committee for Electromagnetic Safety ("ICES"), a committee of the IEEE. To set exposure guidelines, both of these organizations first carefully reviewed the relevant scientific literature to identify any potential adverse effects and the exposure levels where these effects may be observed. Then, they set exposure limits well below the exposure levels at which adverse effects were identified. The number they used to reduce the adverse effect level to an acceptable exposure limit is called a safety factor and was used to account for scientific

uncertainty and variability and for a potentially higher sensitivity of some subgroups of the human population.

ICNIRP published updated limits in 2010. For the general population, the Basic Restriction or ceiling limit on the electric field induced in the central nervous system of the head by a 60-Hz electric field or magnetic field is 0.024 volts per meter (V/m). ICES has recommended a Basic Restriction of 0.0178 V/m in the head for exposure to 60-Hz magnetic or electric fields.[2]

The exposures to EMF that are calculated to produce internal electric fields equal to the most conservative Basic Restriction, the ICES limit, are 9,146 milligauss (mG)[3] and 26.8 kilovolts per meter (kV/m) (Kavet et al., 2010).

Q. How do the AC electric and magnetic fields calculated for the project compare to the basic restrictions in these guidelines?

A. The magnetic field at the full-rating of the proposed 345-kV AC line and the electric field at a 5% overvoltage of these conductors for all segments of the proposed route are well below the ICNIRP and ICES Basic Restrictions as described above. The magnetic field at the edges of the right-of-way ("ROW") along the route will vary between 0.1 mG and 92 mG except for an approximately 2000-foot segment where the magnetic field on one side of the ROW is calculated to be 127 mG. The electric field at the edges of the ROW will vary between 0.0 to 1.7 kV/m except for the approximately 2000-foot segment where the maximum electric field on one ROW edge will be 2.7 kV/m.

Q. Have potential long-term effects of AC EMF been studied and considered as well?

A. Yes. Since the 1970s, numerous scientific studies have examined the potential for long- term effects of exposure to EMF. These studies include studies of human populations, that is, epidemiologic studies, and laboratory studies of animals, tissues, and cells. These scientific

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[2] Despite the widespread description of ICNIRP's reference values or ICES's maximum permissible exposure values as exposure limits, they are just screening values. Measured values below these screening values are specified as complying with the Basic Restrictions, but higher exposures are permitted if it can be shown that the electric field *in situ* does not exceed the Basic Restrictions identified above.

[3] One milligauss (mG) = 0.001 Gauss (G).

investigations examined the potential link of both cancer and non-cancer outcomes among children and adults with occupational and residential exposures.

To evaluate whether the scientific evidence overall suggests the existence of any potential long-term effects, the relevant scientific literature needs to be evaluated in its entirety. Individual studies may be subject to chance variation, potential biases, and confounding due to limitations in the study design, conduct of the study, or in the analyses and interpretation of the results. Thus, scientifically valid conclusions about potential effects may not be drawn from individual studies. An overall assessment of the evidence for scientific and health agencies is done by multi-disciplinary scientific panels, due to the large number and complexity of these scientific studies.

Q. What reviews of EMF research have been performed and what are their conclusions regarding human health?

A. A number of expert panels convened on behalf of scientific, health, and government agencies have evaluated the available scientific literature on potential EMF effects. These agencies include the U.S. National Institute for Environmental Health Sciences ("NIEHS") in 1998, the IARC in 2002, the National Radiological Protection Board of Great Britain in 2004, the WHO in 2007, ICNIRP in 2010, and the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks ("SCENIHR") in 2015. None of these agencies concluded that the evidence, overall, suggests the existence of any adverse health effects in association with environmental exposure to EMF below scientifically-established exposure guidelines. While these agencies recognized the limited evidence based on a statistical association in some of the childhood leukemia epidemiologic studies, they point out that other factors such as chance, bias, and confounding could not be excluded as an explanation for the association. These agencies also concluded that the association is not supported by the results of lifetime exposure studies of laboratory animals that have not identified excess cancer of any type related to the level of exposure to magnetic fields. In addition, there is currently no known biophysical mechanism that would explain a potential carcinogenic effect of EMF.

With respect to the overall evidence on potential long-term effects, the WHO currently states on its website that "[b]ased on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health

consequences from exposure to low level electromagnetic fields."[4] ICNIRP has also considered the scientific literature on potential long-term effects and stated that "[i]t is the view of ICNIRP that the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leukemia is too weak to form the basis for exposure guidelines. In particular, if the relationship is not causal, then no benefit to health will accrue from reducing exposure" (ICNIRP, 2010, p. 824).

Q. Have potential AC EMF effects on animals been investigated?

A. Yes. As part of the human health effects research, a large number of studies have been conducted using various laboratory animal species, most commonly rodents, such as rats and mice. No consistent or convincing evidence has emerged from these studies to support the existence of any health effects. Overall, the WHO classified evidence from laboratory animal studies as "inadequate" for any potential health effects. These findings, similar to the way they were used in human health risk assessments, may be extrapolated to other animal species, such as domestic animals and wildlife, thus providing no support for any potential effects.

A considerable amount of scientific research has been conducted involving livestock, although in a less systematic manner. Both observational and experimental studies on livestock were conducted, mostly prompted by economic considerations, and these studies primarily investigated outcomes of reproduction, milk production, and growth. The most commonly-studied species included cattle, sheep, and swine. Among farm animals, the most systematic research program studied behavioral, reproductive, and productivity parameters in dairy cattle at McGill University in Québec, Canada. These studies exposed dairy cattle to AC electric fields (up to 10 kV/m) and AC magnetic fields (up to 300 mG) separately and in combination. While some of the studies reported small differences in some of the investigated parameters, these differences were within physiological ranges and showed no consistent pattern. Overall, no consistent or convincing evidence has emerged to support any adverse effects in livestock.

Studies conducted in the 1980s with commercial honeybees reported reduced hive weight and increased mortality among bees exposed to electric fields above 4.1 kV/m. Later studies, however, demonstrated that these results were due to indirect effects, attributable to small shocks

[4] http://who.int/peh-emf/about/WhatisEMF/en/index1.html

induced by the electric fields on the metallic components of the hives and not direct effects of the electric fields on bees themselves. These indirect effects may be easily prevented by shielding the hives with a grounded metallic cover over the hives or by using hives without metallic components. More recent studies of native bees in AC transmission line corridors indicated no adverse effects of EMF on bee abundance, diversity, larval development, or behavior such as floral visitation and pollination success. There were also more spatially and numerically rare species and richer bee communities in AC transmission line corridors than at the grassy fields away from transmission lines.

Q. Were potential AC EMF effects on plants investigated?

A. Yes. Both laboratory and field studies have been conducted to examine potential effect of EMF from transmission lines on plants, including agricultural crops and trees, and forest and woodland vegetation. These investigations include studies of seed germination, seedling emergence and growth, leaf area per plant, flowering, seed production, longevity, and biomass production. While the results were variable, no consistent pattern for potential effects were observed. Overall, no confirmed adverse effects on plants were reported due to EMF exposure at levels that could be expected in the vicinity of the proposed transmission lines.

Summary of Assessment Relevant to the Proposed DC Transmission Line

Q. What are the conclusions of health and scientific agencies regarding static magnetic and electric fields and space charge?

A. None of the reviews conducted by the following agencies concluded that exposure to static electric and magnetic fields and space charge at levels associated with the proposed project would pose a likely health threat to the public.

- International Agency for Research on Cancer (IARC)
- International Commission on Nonionizing Radiation Protection (ICNIRP)
- International Committee on Electromagnetic Safety (ICES)
- National Radiological Protection Board (NRPB)
- Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)
- U.S. Food and Drug Administration (FDA)
- World Health Organization (WHO)

Q. Are the projected levels of static electric and magnetic fields from the Northern Pass DC line below recommended limits on human exposure in guidelines?

A. Yes. Neither the U.S. federal government nor any state has proposed standards or guidelines for static electric fields and space charge. ICNIRP (2009) and the FDA (2003) have limits on exposure to static magnetic fields. For the general public the ICNIRP limit is 4,000 Gauss (G). The exposure limits for adults and children to static magnetic fields from magnetic resonance (MRI) imaging scanners are 40,000 G and 80,000 G, respectively. The NRPB (2004) noted that static electric-field exposures above 25 kV/m were associated with annoyance from perception of surface charge on the skin. The maximum levels of the static electric and magnetic fields on the Project's ROW and beyond are below the exposure levels recommended by these agencies and organizations.

Q. Even if the static electric and magnetic fields from the Northern Pass DC line are below levels cited by the agencies referenced above, are they outside the range of our common exposures?

A. No. We all experience a naturally-occurring static electric field of about 0.13 kV/m under normal atmospheric conditions; as storm fronts approach, this can increase to 20 – 40 kV/m. Static electric fields are also found in offices and homes—such as the static charges that occur when walking across a carpet and the static charges on clothing; these indoor sources of static electric fields are closer and stronger sources of electric-field exposures (100 – 500 kV/m). In contrast, the calculated maximum static electric field at the edge of the right-of-way in fair weather is ≤5.7 kV/m, and will increase to ≤8.8 kV/m during foul weather.

The earth is the dominant source of a naturally-occurring static magnetic field, which causes a compass needle to point to the magnetic north pole. The intensity of this geomagnetic field in New Hampshire is approximately 530 mG. Other common sources of static magnetic fields in the range of 3,000 – 10,000 mG include permanent magnets (which are found in appliances, toys, and medical devices) and battery-powered appliances. Lower static magnetic fields < 3,000 mG are associated with DC-powered electrified railway systems. Far higher magnetic fields are produced by MRI scanners and certain industrial processes. The maximum calculated static magnetic field contributed by the DC line at full-rated loading at the edge of the right-of-way is calculated to be ≤79 mG for the overhead portion of the route and ≤58 mG at

25 feet from the centerline for portions of the underground route. Thus, the magnetic field from the line is lower here and away from the line than that of the earth; however, depending upon the orientation of the Project's DC line with respect to the earth's magnetic field, the magnetic field from the line can either add to the earth's field or partially cancel the earth's field.

Q. How do static magnetic fields interact with organisms and what are their effects?

A. Static magnetic fields at very high intensities are known to interact with tissue by several mechanisms. None of these mechanisms, however, predict harm from exposures at the low intensities of static magnetic fields associated with the earth's geomagnetic field or the proposed DC transmission line. Reviews by several scientific and health agencies do not report that static magnetic fields have adverse effects at environmental levels. Even exposures to magnetic fields from conventional MRI scanners and experimental MRI scanners at levels 15,000 times greater than static magnetic fields from the earth or the Project's DC line are reported to have few direct effects in short-term studies. Even higher intensity static magnetic fields have been tested on animals and for longer durations. In general, biological effects were most clearly elicited by static magnetic fields at intensities above 1 Tesla (T) (10,000 G).

Q. How do static electric fields interact with organisms and what are their effects?

A. Static electric fields affect the distribution of surface charge on the body, but do not enter it to any significant degree. At sufficiently high levels the field can be perceived by the movement of hair on the body such as that produced by a very faint breeze. The electric field from the Project's DC line would be too weak to be easily detected by most people even under the line. If a person contacts a large vehicle (e.g., a tractor trailer), under the line that is very well insulated from ground, he or she might perceive a microshock, similar to what a person might experience after shuffling across a carpet and touching a metal object. Published studies of static electric fields on experimental animals were reviewed, but it cannot be concluded from these studies that any observed biological effects from single studies were due to direct biological effects of the field at levels relevant to those of the project. Indirect effects resulting from stimulation of body fur are the most plausible explanation for responses reported above 30 kV/m.

Q. Are the space charge levels from the Project's DC line outside the range of common experience?

A. No. The levels of air ions calculated at the edge of the ROW of the DC line are within the range of levels that can be encountered in the environment naturally and from varying technologies.

Electrical charges in the air are formed by many natural energy sources. These sources include charges formed by the earth and its atmosphere as well as energy released by evaporation (e.g., boiling water in a tea kettle, which produces 1,000,000 – 10,000,000 ions per cubic centimeter [cm^3]), friction from blowing dust or snow, flames, and weather events. These positive and negative charges on gas molecules are quickly surrounded by clusters of water molecules and do not persist very long (i.e., tens of seconds) before they are neutralized by molecules carrying the opposite charge or when the charge is transferred to microscopic solid or liquid particles in the air (aerosols). Together, air ions and charged aerosols are referred to as space charge. Positive air ions and aerosols result from air molecules or particles that have lost electrons; negative air ions or aerosols are air molecules and particles that have picked up the excess electrons.

Air ions are present everywhere in our environment. For example, clean rural air typically contains about 500 to 2,000 small positive air ions/cm^3 and slightly fewer small negative air ions; negative ion levels can rise to 5,000 – 20,000 ions/cm^3 near waterfalls. In large towns, levels up to 80,000 air ions/cm^3 have been measured. The presence of raindrops, insects, and other material on the DC transmission line and the 345-kV AC transmission line conductors will accelerate corona activity and space charge production. Corona only occurs if the gradient of the electric field at the conductor surface exceeds a certain threshold or onset value. During fair weather, the corona activity on the proposed line will be sporadic, but will be fairly continuous in foul weather. While corona is present on conductors of both DC and AC transmission lines, corona activity leads to negligible levels of space charge from AC transmission lines because, once created, most all air ions are attracted back to the conductor when its polarity changes during each cycle.

Q. Has much research has been done on space charge?

A. Yes, many studies have been done, mostly to investigate possible therapeutic applications to favorably affect mood and respiratory conditions. No scientific or regulatory agency has determined that space charge poses a threat to health or the environment. No mechanism has been confirmed by which air ions or the charge on aerosols would have direct effects on the body, but like static electric fields, space charge at very high levels can be perceived by hair stimulation.

Two recent comprehensive reviews of human subject studies, including meta-analyses of similar studies, have reported on these topics—neither found consistent evidence for effects of either positive or negative ions, except for the possible reduction in indicators of depression at levels more than 10 – 20 fold greater than the maximum levels calculated to be associated with Northern Pass. This response, however, was not related to the duration of exposure. To complement these reviews of human studies, a comprehensive review of more than 50 animal studies in 9 different topic areas was performed. Altogether, the research provided no consistent or reliable evidence that air ions or associated charged aerosols caused any biological responses or adverse effects on the health of the animals. Many of the studies suffer from various reporting and methodological deficiencies.

A potential mechanism for an indirect effect of air ions was evaluated. If air ions were to sufficiently charge passing aerosols, then a small increase in the deposition of aerosols in the respiratory tract might be predicted. The prevalence of electric charges on aerosol particles, however, is similar across a wide range of environments, including around DC and AC transmission lines, and the number of charges per particle calculated or measured around higher voltage DC lines is too low to enhance deposition of aerosols in the respiratory tract.

The Ministry of Health of the Russian Federation has recommended that air ions be increased in indoor environments up to 50,000 ions/cm^3, but the basis for this recommendation, except to improve air quality, was not provided.

Q. Has research been done on potential effects of static electric and magnetic fields and space charge on livestock, wild animals, and plants?

A. Yes. Comprehensive experimental field studies around DC transmission lines operating at ±400 kV and ±500 kV have not reported adverse effects on cattle or crops. A

systematic assessment of plants and animals around a ±400 kV DC transmission line reported increases and decreases in some populations, but was unable to conclude from this assessment whether the observations reflected a change in the physical habitat or the electrical environment. Other laboratory studies do not indicate that the weak magnetic field from the DC line would adversely affect species that can make use of the geomagnetic field for orientation or navigation. Field and laboratory studies do not indicate that the electric field from the line would be high enough to affect plants and the beneficial effects on plant growth suggested by some studies of magnetic fields only appeared at levels thousands of times greater than would be produced by the Project's DC line.

Conclusion

Q. On the basis of your assessment, please summarize your conclusions and assess the potential for health effects from the Project.

A. My evaluation considered exposures to electric and magnetic fields, static electric and magnetic fields, and space charge that will be associated with the operation of the Project and existing transmission and distribution lines. At the edges of the ROW and beyond, these exposures are within the ranges commonly encountered from other sources. The levels of fields from the Project's 345 kV AC transmission line and the DC line, and space charge from the latter, are all below applicable limits in guidelines designed to protect public health. My evaluation additionally considered the mechanisms by which these exposures may interact with organisms and involved the review of the scientific studies of humans, experimental animals, livestock, wild animals, and plants. Neither this review nor the reviews of the literature performed for scientific and health agencies identified mechanisms of interaction or exposures at the levels associated with the electrical environment of the Project that would predict any likely harm to public health or the environment. The mostly likely effect, if it occurs at all, would be non-adverse perception of electric fields.

Q. Is it your testimony that the Project's AC and DC lines would not pose an unreasonable adverse effect on public health and safety?

A. Yes, in my judgement the weight of the scientific evidence clearly supports that conclusion that the Project would not pose an unreasonable adverse effect to public health and

safety. Moreover, that judgement is shared by scientific and health agencies that also have reviewed the scientific evidence.

Q. Have you seen the draft environmental impact statement released by the department of energy for the project?

A. Yes. The findings are consistent with my testimony.

Q. Does this conclude your testimony?

A. Yes, it does.

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ATTACHMENT A

William H. Bailey, Ph.D.

Principal Scientist

Professional Profile

Dr. William H. Bailey is a Principal Scientist in Exponent's Health Sciences practice. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental and occupational health issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey has investigated exposures to alternating current, direct current, and radiofrequency electromagnetic fields, 'stray voltage', and electrical shock, as well as to a variety of chemical agents and air pollutants. He is particularly well known for his research on potential health effects of electromagnetic fields and has served as an advisor to numerous state, federal, and international agencies. Currently, he is involved in research on exposures to marine life from submarine cables and respiratory exposures to ultrafine- and nanoparticles. Dr. Bailey is a visiting scientist at the Cornell University Medical College and has lectured at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Academic Credentials and Professional Honors

Ph.D., Neuropsychology, City University of New York, 1975
M.B.A., University of Chicago, 1969
B.A., Dartmouth College, 1966

Sigma Xi; The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety (Subcommitee 3, Safety Levels with Respect to Human Exposure to Fields (0 to –3 kHz) and Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz); Elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society, 1998–2001

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Book Chapters

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Charry JM, Bailey WH, Weiss JM. Critical annotated bibliographical review of air ion effects on biology and behavior. Rockefeller University, New York, NY, 1982.

Bailey WH. Avoidance behavior in rats with hereditary hypothalamic diabetes insipidus. Dissertation, City University of New York, 1975.

Selected Invited Presentations

Bailey WH. Measurements of charged aerosols around DC transmission lines and other locations. International Committee on Electromagnetic Safety TC95/ Subcommittee 3: Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 – 3 kHz, December 2011.

Bailey WH, Erdreich LS. Human sensitivity and variability in response to electromagnetic fields: Implications for standard setting. International Workshop on EMF Dosimetry and Biophysical Aspects Relevant to Setting Exposure Guidelines. International Commission on Non-Ionizing Radiation Protection, Berlin, March 2006.

Bailey WH. Research-based approach to setting electric and magnetic field exposure guidelines (0-3000 Hz). IEEE Committee on Electromagnetic Safety, December 2005.

Bailey WH. Conference Keynote Presentation. Research supporting 50/60 Hz electric and magnetic field exposure guidelines. Canadian Radiation Protection Association, Annual Conference, Winnipeg, June 2005.

Bailey WH. Scientific methodology for assessing public health issues: A case study of EMF. Canadian Radiation Protection Association, Annual Conference, Public Information for Teachers, Winnipeg, June 2005.

Bailey WH. Assessment of potential environmental effects of electromagnetic fields from submarine cables. Connecticut Academy of Science and Engineering, Long Island Sound Bottomlands Symposium: Study of Benthic Habitats, July 2004.

De Santo RS, Coe M, Bailey WH. Environmental justice assessment and the use of GIS tools and methods. National Association of Environmental Professionals, 27th Annual Conference, Dearborn, MI, June 2002.

Bailey WH. Applications to enhance safety: Research to understand and control potential risks. Human Factors and Safety Research, Volpe National Transportation Systems Center/Dutch Ministry of Transport, Cambridge, MA, November 2000.

Bailey WH. EMF health effects review. EMF Exposure Guideline Workshop, Brussels Belgium, June 2000.

Bailey WH. Dealing with uncertainty when formulating guidelines. EMF Exposure Guideline Workshop, Brussels Belgium, June 2000.

Bailey WH. Field parameters: Policy implications. EMF Engineering Review Symposium, Status and Summary of EMF Engineering Research, Charleston, SC, April 1998.

Bailey WH. Principles of risk assessment: Application to current issues. Symposium on EMF Risk Perception and Communication, World Health Organization, Ottawa, Canada, August 1998.

Bailey WH. Current guidelines for occupational exposure to power frequency magnetic fields. EPRI EMF Seminar, New Research Horizons, March 1997.

Bailey WH. Methods to assess potential health risks of cell telephone electromagnetic fields. IBC Conference—Cell Telephones: Is there a Health Risk? Washington, DC, June 1997.

Bailey WH. Principles of risk assessment and their limitations. Symposium on Risk Perception, Risk Communication and its Application to EMF Exposure, International Commission on Non-Ionizing Radiation Protection, Vienna, Austria, October 1997.

Bailey WH. Probabilistic approach for setting guidelines to limit induction effects. IEEE Standards Coordinating Committee 28: Non-Ionizing Radiation, Subcommittee 3 (0–3 kHz), June 1997.

Bailey WH. Power frequency field exposure guidelines. IEEE Standards Coordinating Committee 28: Non-Ionizing Radiation, Subcommittee 3 (0–3 kHz), June 1996.

Bailey WH. Epidemiology and experimental studies. American Industrial Hygiene Conference, Washington, DC, May 1996.

Bailey WH. Review of 60 Hz epidemiology studies. EMF Workshop, Canadian Radiation Protection Association, Ontario, Canada, June 1993.

Bailey WH. Biological and health research on electric and magnetic fields. American Industrial Hygiene Association, Fredrickton, New Brunswick, Canada, October 1992.

Bailey WH. Electromagnetic fields and health. Institute of Electrical and Electronics Engineers, Bethlehem, PA, January 1992.

Bailey WH, Weiss JM. Psychological factors in experimental heart pathology. Visiting Scholar Presentation, National Heart Lung and Blood Institute, March 1977.

Presentations

Williams AI, Bailey WH. Toxicologic assessment of air ion exposures in laboratory animals. Poster presentation at 53rd Annual Meeting of the Society of Toxicology, Phoenix, AZ, March 26, 2014.

Perez V, Alexander DD, Bailey WH. Air ions and mood outcomes: A review and meta-analysis. Poster presentation at the American College of Epidemiology, Chicago, IL, September 8–11, 2012.

Shkolnikov Y, Bailey WH. Electromagnetic interference and exposure from household wireless networks. Product Safety Engineering Society Meeting, San Diego, CA October 2011.

Nestler E, Trichas T, Pembroke A, Bailey W. Will undersea power cables from offshore wind projects affect sharks? North American Offshore Wind Conference & Exhibition, Atlantic City, NJ, October 2010.

Nestler E, Pembroke A, Bailey W. Effects of EMFs from undersea power lines on marine species. Energy Ocean International, Ft. Lauderdale, FL, June 2010.

Pembroke A, Bailey W. Effects of EMFs from undersea power cables on elasmobranchs and other marine species. Windpower 2010 Conference and Exhibition, Dallas, TX, 2010.

Bailey WH. Clarifying the neurological basis for ELF guidelines. Workshop on Practical Implementation of ELF and RF Guidelines. The Bioelectromagnetics Society 29th Annual Meeting, Kanazawa, Japan, June 2007.

Sun B, Urban B, Bailey W. AERMOD simulation of near-field dispersion of natural gas plume from accidental pipeline rupture. Air and Waste Management Association: Health Environments: Rebirth and Renewal, New Orleans, LA, June 2006.

Bailey WH, Johnson G, Bracken TD. Method for measuring charge on aerosol particles near AC transmission lines. Joint Meeting of The Biolectromagnetics Society and The European BioElectromagnetics Association, Dublin Ireland, June 2005.

Bailey WH, Bracken TD, Senior RS. Long-term monitoring of static electric field and space charge near AC transmission Lines. The Bioelectromagnetics Society, 26th Annual Meeting, Washington, DC, June 2004.

Bailey WH, Erdreich L, Waller L, Mariano K. Childhood leukemia in relation to 25-Hz and 60-Hz magnetic fields along the Washington DC—Boston rail line. Society for Epidemiologic Research, 35th Annual Meeting, Palm Desert CA, June 2002. American Journal of Epidemiology 2002; 155:S38.

Erdreich L, Klauenberg BJ, Bailey WH, Murphy MR. Comparing radiofrequency standards around the world. Health Physics Society 43rd Annual Meeting, Minneapolis, MN, July 1998.

Bracken TD, Senior RS, Rankin RF, Bailey WH, Kavet R. Relevance of occupational guidelines to utility worker magnetic-field exposures. Second World Congress for Electricity and Magnetism in Biology and Medicine, Bologna, Italy, June 1997.

Weil DE, Erdreich LS, Bailey WH. Are 60-Hz magnetic fields cancer causing agents? Mechanisms and Prevention of Environmentally Caused Cancers, The Lovelace Institutes 1995 Annual Symposium, La Fonda, Santa Fe, NM, October 1995.

Bailey WH. Neurobiological research on extremely-low-frequency electric and magnetic fields: A review to guide future research. Sixteenth Annual Meeting of the Bioelectromagnetics Society, Copenhagen, Denmark, June 1994.

Blondin J-P, Nguyen D-H, Sbeghen J, Maruvada PS, Plante M, Bailey WH, Goulet D. The perception of DC electric fields and ion currents in human observers. Annual Meeting of the Canadian Psychological Association, Penticton, British Columbia, Canada, June 1994.

Erdreich LS, Bailey WH, Weil DE. Science, standards and public policy challenges for ELF fields. American Public Health Association 122nd Annual Meeting, Washington, DC, October 1994.

Bailey WH, Charry JM. Particle deposition on simulated VDT operators: Influence of DC electric fields. 10th Annual Meeting of the Bioelectromagnetics Society, June 1988.

Charry JM, Bailey WH. Contribution of charge on VDTs and simulated VDT operators to DC electric fields at facial surfaces. 10th Annual Meeting of the Bioelectromagnetics Society, June 1988.

Bailey WH, Charry, JM. Dosimetric response of rats to small air ions: Importance of relative humidity. EPRI/DOE Contractors Review, November 1986. Charry JM, Bailey WH, Bracken TD (eds). DC electric fields, air ions and respirable particulate levels in proximity to VDTs. International Conference on VDTs and Health, Stockholm, Sweden, June 12–15 1986.

Charry JM, Bailey WH. Air ion and DC field strengths at 10^4 ions/cm^3 in the Rockefeller University Small Animal Exposure Chambers. EPRI/DOE Contractors Review, November 1985.

Charry JM, Bailey WH. DC Electrical environment in proximity to VDTs. 7th Annual Meeting of the Bioelectromagnetics Society, June 1985.

Bailey WH, Collins RL, Lahita RG. Cerebral lateralization: Association with serum antibodies to DNA in selected bred mouse lines. Society for Neuroscience, 1985.

Kavet R, Bailey WH, Charry JM. Respiratory neuroendocrine cells: A plausible site for air ion effects. Seventh Annual Meeting of The Bioelectromagnetics Society, June 1985.

Bailey WH, Charry JM. Measurement of neurotransmitter release and utilization in selected brain regions of rats exposed to DC electric fields and atmospheric space charge. 23rd Hanford Life Sciences Symposium, Richland, WA, October 1984.

Bailey WH, Charry JM, Weiss JM, Cardle K, Shapiro M. Regional analysis of biogenic amine turnover in rat brain after exposure to electrically charged air molecules (air ions). Society for Neuroscience, 1983.

Bailey WH. Biological effects of air ions: Fact and fancy. American Institute of Medical Climatology Conference on Environmental Ions and Related Biological Effects, October 1982.

Goodman PA, Weiss JM, Hoffman LJ, Ambrose MJ, Bailey WH, Charry, JM. Reversal of behavioral depression by infusion of an A2 adrenergic agonist into the locus coeruleus. Society for Neuroscience, November 1982.

Charry JM, Bailey WH. Biochemical and behavioral effects of small air ions. Electric Power Research Institute Workshop, April 1981.

Bailey WH, Alsonso DR, Weiss JM, Chin S. Predictability: A psychologic/ behavioral variable affecting stress-induced myocardial pathology in the rat. Society for Neuroscience, November 1980.

Salman SL, Weiss JM, Bailey WH, Joh TH. Relationship between endogenous brain tyrosine hydroxylase and social behavior of rats. Society of Neuroscience, November 1980.

Bailey WH, Maclusky S. Appearance of creatine kinase isoenzymes in rat plasma following myocardial injury produced by isoproterenol. Fed Assoc Soc Exp Biol, April 1978.

Bailey WH, Maclusky S. Appearance of creatine kinase isoenzymes in rat plasma following myocardial injury by isoproterenol. Fed Proc 1978; 37:889.

Bailey WH, Weiss JM. Effect of ACTH 4-10 on passive avoidance of rats lacking vasopressin (Brattleboro strain). Eastern Psychological Association, April 1976.

Prior Experience

President, Bailey Research Associates, Inc., 1991–2000
Vice President, Environmental Research Information, Inc., 1987–1990

Head of Laboratory of Environmental Toxicology and Neuropharmacology, New York State Institute for Basic Research, 1983–1987

Assistant Professor, The Rockefeller University, 1976–1983

Academic Appointment

- Visiting Fellow, Department of Pharmacology, Cornell University Medical College, New York, NY, 1986–present

Prior Academic Appointments

- Visiting Scientist, The Jackson Laboratory, Bar Harbor, ME, 1984–1985
- Head, Laboratory of Neuropharmacology and Environmental Toxicology, NYS Institute for Basic Research in Developmental Disabilities, Staten Island, NY, 1983–1987
- Assistant Professor, The Rockefeller University, New York, NY, 1976–1983
- Postdoctoral Fellow, Neurochemistry, The Rockefeller University, New York, NY, 1974–1976
- Dissertation Research, The Rockefeller University, New York, NY, 1972–1974
- CUNY Research Fellow, Dept. of Psychology, Queens College, City University of New York, Flushing, NY, 1969–1971
- Clinical Research Assistant, Department of Psychiatry, University of Chicago; Psychiatric Psychosomatic Inst., Michael Reese Hospital, and Illinois State Psychiatric Inst, Chicago, IL, 1968–1969

Teaching Appointments

- Lecturer, University of Texas Health Science Center, Center for Environmental Radiation Toxicology, San Antonio, TX, 1998
- Lecturer, Harvard School of Public Health, Office of Continuing Education, Boston, MA, 1995, 1997
- Lecturer, Rutgers University, Office of Continuing Education, New Brunswick, NJ, 1991–1995
- Adjunct Assistant Professor, Queens College, CUNY, Flushing, NY, 1978
- Lecturer, Queens College, CUNY, Flushing, NY, 1969–1974

Editorship

- Associate Editor, Non-Ionizing Radiation, *Health Physics*, 1996–present

Advisory Positions

- RWTH Aachen University. Workshop on human perception thresholds in static electric fields from high-voltage direct current (HVDC) transmission lines, 2015
- ZonMw – Netherlands Organization for Health Research and Development, 2012; 2007-2008, reviewer for National Programme on EMF and Health
- US Bureau of Ocean Energy Management, Regulation and Enforcement, 2009–2010
- Canadian National Collaborating Centre for Environmental Health, reviewer of Centre reports, 2008
- Island Regulatory and Appeals Commission, province of Prince Edward Island, Canada, 2008
- National Institute of Environmental Health Sciences/ National Institutes of Health, Review Committee, Neurotoxicology, Superfund Hazardous Substances Basic Research and Training Program, 2004

- National Institute of Environmental Health Sciences, Review Committee Role of Air Pollutants in Cardiovascular Disease, 2004
- Working Group on Non-Ionizing Radiation, Static and Extremely Low-Frequency Electromagnetic Fields, International Agency for Research on Cancer, 2000–2002
- Working Group, EMF Risk Perception and Communication, World Health Organization, 1998–2005
- Member, International Committee on Electromagnetic Safety, Subcommittee 3 - Safety Levels with Respect to Human Exposure to Fields (0 to 3 kHz) and Subcommitee 4 - Safety Levels with Respect to Human Exposure (3kHz to 3GHz) Institute of Electrical and Electronics Engineers (IEEE), 1996–present
- Invited participant, National Institute of Environmental Health Sciences EMF Science Review Symposium: Clinical and In Vivo Laboratory Findings, 1998
- Working Group, EMF Risk Perception and Communication, International Commission on Non-Ionizing Radiation Protection, 1997
- U.S. Department of Energy, RAPID EMF Engineering Review, 1997
- Oak Ridge National Laboratory, 1996
- American Arbitration Association International Center for Dispute Resolution, 1995–1996
- U.S. Department of Energy, 1995
- National Institute for Occupational Safety and Health, 1994–1995
- Federal Rail Administration, 1993–1996
- U.S. Forest Service, 1993
- New York State Department of Environmental Conservation, 1993
- National Science Foundation
- National Institutes of Health, Special Study Section—Electromagnetics, 1991–1993
- Maryland Public Service Commission and Maryland Department of Natural Resources, Scientific Advisor on health issues pertaining to HVAC Transmission Lines, 1988–1989

- Scientific advisor on biological aspects of electromagnetic fields, Electric Power Research Institute, Palo Alto, CA, 1985–1989
- U.S. Public Health Service, NIMH: Psychopharmacology and Neuropsychology Review Committee, 1984
- Consultant on biochemical analysis, Colgan Institute of Nutritional Science, Carlsbad, CA, 1982–1983
- Behavioral Medicine Abstracts, Editor, animal behavior and physiology, 1981–1983
- Consultant on biological and behavioral effects of high-voltage DC transmission lines, Vermont Department of Public Service, Montpelier, VT, 1981–1982
- Scientific advisory committee on health and safety effects of a high-voltage DC transmission line, Minnesota Environmental Quality Board, St. Paul, MN, 1981–1982
- Consultant on biochemical diagnostics, Biokinetix Corp., Stamford, CT, 1978–1980

Professional Affiliations

- The Health Physics Society (Affiliate of the International Radiation Protection Society)
- Society for Risk Analysis
- International Society of Exposure Analysis
- New York Academy of Sciences
- American Association for the Advancement of Science
- Air and Waste Management Association
- Society for Neuroscience/International Brain Research Organization
- Bioelectromagnetics Society
- The Institute of Electrical and Electronics Engineers/Engineering in Medicine and Biology Society
- Conseil International des Grands Réseaux Électriques

THE STATE OF NEW HAMPSHIRE

BEFORE THE

SITE EVALUATION COMMITTEE

DOCKET NO. 2015- 06

PRE-FILED DIRECT TESTIMONY OF GARY B. JOHNSON, Ph.D.

IN SUPPORT OF THE
APPLICATION OF NORTHERN PASS TRANSMISSION LLC
AND PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE
D/B/A EVERSOURCE ENERGY
FOR A CERTIFICATE OF SITE AND FACILITY TO CONSTRUCT A NEW HIGH VOLTAGE TRANSMISSION LINE AND RELATED FACILITIES IN NEW HAMPSHIRE

October 16, 2015