

**STATE OF VERMONT
PUBLIC SERVICE BOARD**

Petition of Vermont Electric Power Company, Inc.)
("VELCO") for a Certificate of Public Good authorizing) Docket No. _____
VELCO to construct the so-called Northwest Vermont)
Reliability Project)

**DIRECT TESTIMONY OF
PETER ALEXIS VALBERG, Ph.D.,
GRADIENT CORPORATION,
CAMBRIDGE, MA**

**ON BEHALF OF
VERMONT ELECTRIC POWER COMPANY, INC.**

Dr. Valberg specializes in the area of public health risk assessment of electric and magnetic fields. His testimony addresses whether the Northwest Vermont Reliability Project is expected to have adverse effects on human health and safety.

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1. Introduction and Qualifications of Dr. Valberg

1 Q1. Please state your name, business address and qualifications.

2 A1. My name is Peter Alexis Valberg. I am a Principal at Gradient Corporation, 238 Main Street,
3 Cambridge, MA 02142. I specialize in the areas of inhalation toxicology, biological
4 modeling of human exposure to environmental agents, and human health risk assessment.
5 Some of the specific agents I have studied extensively include air pollutants, groundwater
6 contaminants, radio wave frequencies ("RF"), and electric and magnetic fields ("EMF").

7 I hold an A.B. degree, *summa cum laude*, in Physics and Mathematics from Taylor
8 University, both M.A. and Ph.D. degrees in Physics from Harvard University, and an M.S.
9 degree in Human Physiology from the Harvard University School of Public Health
10 ("HSPH").

11 For 25 years, I served as a faculty member in the Department of Environmental
12 Health at HSPH, where I researched and taught toxicology, cell biology, environmental
13 health, and public health. One of the research grants I directed at HSPH was funded by the
14 National Cancer Institute, and was on the topic of "Magnetic Field Effects on Macrophages"
15 (where 'macrophages' are a type of lung cell that cleans the lung of particles deposited there
16 from dust present in the air we breathe).

1 I have served on advisory panels for the National Institutes of Health (“NIH”), the
2 Health Effects Institute, and the Environmental Protection Agency (“EPA”). I am a member
3 of the International Society for Environmental Epidemiology, the Health Physics Society, the
4 Bioelectromagnetics Society, and the Committee on Man and Radiation (“COMAR”).
5 Through the Harvard Center for Risk Analysis, I served as a member of the “Harvard
6 Advisory Committee on EMF and Human Health” as well as the “Peer Review Board on
7 Cellular Technology and Human Health.” I assisted the Health Effects Institute in
8 determining the feasibility of launching an EMF research program, and I have published a
9 summary document on “EMF Mechanisms” in the journal *Radiation Research*. At the
10 request of the International Congress on Radiation Research (“ICRR”), I organized and
11 chaired a symposium on “Physical aspects of EMF / RF effects on Biological Systems,” at
12 the 11th Annual ICRR meeting in Dublin, Ireland (1999). Recently, I helped organize a
13 conference in the Boston area on “Childhood leukaemia: Electric and Magnetic Fields as
14 Possible Risk Factors.” A summary of this workshop is currently (2003) in press at the
15 journal *Environmental Health Perspectives*.

16 My resume is attached to my prefiled testimony as VELCO Exhibit PAV-1. VELCO
17 Exhibit PAV-2 lists my testimony before regulatory boards on the issue of EMF health
18 effects.

19
20 Q2. What is the purpose of your testimony in this proceeding?

21 A2. I was asked by Vermont Electric Power Company, Inc. (“VELCO”) to assess the potential
22 health effects of EMF exposure related to the proposed VELCO Northwest Vermont
23 Reliability Project (“NRP” or “Project”), which is the subject of this proceeding.

24
25 Q3. Please summarize your testimony

26 A3. Section 2 provides an overview of EMF and Health. Section 3 summarizes expert opinion
27 and applicable regulatory guidance as it applies to potential health impacts. Section 4

1 assesses the potential health effects of the EMFs calculated for the Project. Section 5
2 summarizes the conclusions of the analysis.

3
4 My review of (1) the current status of biological, public health, and medical research
5 on the possible effects of power-line EMF on health, (2) the current scientific consensus
6 documents and regulatory guidelines on allowable EMF exposures, and (3) the EMF levels
7 predicted to be associated with this Project, leads me to conclude that the EMF that will be
8 produced as a result of this Project will not have adverse public health effects.

9
10 **2. Overview of EMF Definitions, Sources, and Magnitudes**

11 Q4. Where does EMF come from?

12 A4. All matter contains electrically-charged particles. Most objects are electrically neutral
13 because positive and negative charges are present in equal numbers. When the balance of
14 electric charges is altered, we experience electrical effects, such as the static electricity
15 attraction between a comb and our hair, or drawing sparks after walking on a synthetic rug
16 in the wintertime. Electrical effects both in nature and in society's use of electricity
17 (generation, transmission, consumption) produce EMF.

18 The work put into electrically charging something is measured by the *voltage*. The
19 units of work-per-unit-charge are *volts* or *kilovolts* (kV; 1kV = 1,000 V). Voltage is the
20 "pressure" of the electricity, and is analogous to the pressure of water in a plumbing system.
21 Electric charges push and pull on each other. Opposite charges (*i.e.*, + and -) attract and like
22 charges (*i.e.*, + and +) repel. Scientists explain these forces by saying that each electric
23 charge generates an *electric field* that exerts force on other nearby charges. That is, an
24 electric field is a measure of force per unit charge (newtons per coulomb), but is usually
25 expressed in units of volts per meter (V/m).

26 When electric charges move, an electric *current* exists, and a current generates a
27 *magnetic field*. Units of electric current are *amperes* (A), and current measures the "flow"

1 of electricity, somewhat like the flow of water in a plumbing system. The current of moving
2 electric charges produces a magnetic field that exerts force on other moving charges. That
3 is, a magnetic field expresses the force per unit length of current-carrying wire (newtons per
4 amp-meter), but is usually expressed in units of gauss (G) or milligauss (mG).

5 For example, electric motors use magnetic-field forces to turn electricity into
6 mechanical work. Conversely, generators rotate loops of wire through magnetic fields and
7 generate electric power from mechanical energy.

8
9 Q5. Where do people encounter magnetic fields in everyday life?

10 A5. Everyone is exposed to a wide variety of natural and man-made electric and magnetic fields.
11 EMF fields can be slowly varying or steady (often called “DC fields”) or can vary in time
12 (often called “AC fields”). When the time variation of interest corresponds to that of power
13 line currents, *i.e.*, 60 changes per second, the fields may be called “60-Hz” EMF.

14 Man-made magnetic fields are common in everyday life. Many childhood toys
15 contain magnets. “Permanent magnets” generate strong, steady magnetic fields. Typical toy
16 magnets (*e.g.*, “refrigerator-door” magnets) produce 100,000 – 500,000 mG. Magnetic
17 resonance imaging (“MRI”) is a medical diagnostic procedure that puts humans in much
18 larger fields (20,000,000 mG) and is preferred over an X-ray because of its safety. These are
19 primarily “DC” or steady magnetic fields.

20 The earth’s atmosphere produces slowly varying electric fields (about 100 to 10,000
21 V/m) that occasionally discharge as lightning strikes. Magnetic fields are produced by the
22 earth’s core, and can be easily demonstrated with a compass needle. The size of the earth’s
23 magnetic field in the North America is about 570 mG. Knowing the strength of the earth’s
24 fields provides a perspective on the size of power line electric and magnetic field
25 measurements. The earth’s steady electric and magnetic fields do not have the 60-cycles-
26 per-second (60-Hz) time variation characteristic of power line EMF, but are otherwise

1 indistinguishable. For example, a magnet spinning at 60 Hz can produce a magnetic field
2 just like the magnetic field produced by 60-Hz power line currents.

3 Electric power transmission lines, distribution lines, and electric wiring in buildings
4 carry alternating currents (“AC”) and voltages that change size and direction at 60 times per
5 second = 60 Hz. These 60-Hz currents and voltages produce 60-Hz EMF. The size of the
6 magnetic field is proportional to the current, and the size of the electric field is proportional
7 to the voltage; both fields decrease with distance from the electrical wires. When EMFs are
8 produced by different sources (*e.g.*, adjacent wires) the net EMF may be the sum total of
9 both, or the net EMF may be less (that is, EMFs may add or partially cancel). Inside
10 residences, typical baseline 60-Hz magnetic fields (away from appliances) range from 0.5 to
11 2.0 mG. These fields arise from electric appliances, outdoor distribution wiring, indoor
12 wiring, and ground return pathways. The time-varying power line magnetic fields add or
13 subtract to the steady field of the earth (570 mG).

14 Higher magnetic field levels are found near operating appliances. For example, can
15 openers, mixers, blenders, refrigerators, fluorescent lamps, electric ranges, clothes washers,
16 toasters, portable heaters, vacuum cleaners, electric tools, and many other appliances produce
17 magnetic fields of size 40 – 300 mG at distances of 1 foot.¹ Magnetic fields from
18 personal-care appliances held within ½ foot (*e.g.*, shavers, hair dryers, massagers) can
19 produce 600 – 700 mG. In the school and work environment, copy machines, vending
20 machines, video-display terminals, electric tools, lights, and motors are all sources of EMFs.

21
22 **3. Expert Opinion and Regulatory Guidance About EMF Power Line Exposure**

23 Q6. What is the state of the scientific knowledge about the health effects of exposure to power
24 line EMF?

¹ National Institute of Environmental Health Sciences, Electric and Magnetic Fields Associated with the Use of Electric Power, Questions and Answers, NIH Publication 02-4493 (2002). Research Triangle Park, NC. 64 pp. (<http://www.niehs.nih.gov/emfrapid/booklet/home.htm>)

1 A6. The sum of scientific evidence currently available from a vast amount of EMF research and
2 human experience does not establish that environmental levels of power-line EMF are
3 hazardous to health.

4 EMF epidemiology studies have received the most attention. “Epidemiology” is a
5 statistical science that looks for correlations between patterns of disease occurrence and
6 patterns of human lifestyle, diet, environment, or exposure. An epidemiologic study
7 published in 1979² suggested that living near electric power distribution lines was linked to
8 an increased risk of childhood cancer. In this and a number of other studies, the actual EMF
9 levels that children had been exposed to were unknown, so the researchers developed a
10 surrogate for past EMF exposures that was based on the proximity, number, and size of
11 electric-utility distribution lines near the homes. This summary description of the electric
12 power distribution line configuration near a home was called its “wire code,” and homes with
13 high wire codes (and presumably higher EMF levels) were found to be disproportionately
14 represented in the cancer cases as opposed to control children.

15 Since this first study, a number of epidemiologic studies have examined associations
16 between disease and the “wire code” classification of homes. If an association was seen with
17 the wire code classification, it was interpreted as showing an effect of EMF on the disease
18 being studied. However, repeat studies showed that the associations with wire code were
19 weak and inconsistent. Moreover, the associations often weakened or disappeared when
20 actual measured magnetic fields were substituted in place of wire codes. It was found that
21 the wire codes were poor surrogates for actual EMF exposure, but rather, were good
22 surrogates for non-EMF factors such as traffic density, age of the home, rental vs. ownership,
23 and assessed value of the home. This made it unlikely that the wire code associations with

² N.Wertheimer and E.Leeper, *Electrical Wiring Configurations and Childhood Cancer*, Am J. Epidem 109:273-284 (1979).

1 cancer risk were actually an effect of EMF exposure *per se*. That is, it was not possible to
2 isolate the EMF exposure as the “causal” factor in the associations reported.³

3
4 Q7. What are the most important studies undertaken in recent years concerning the possible risks
5 that EMFs pose to humans?

6 A7. Literally hundreds of EMF research studies have been published since the 1979 Wertheimer
7 and Leeper study reported a statistical association between estimated EMF exposure and
8 childhood leukemia in certain residential neighborhoods in Denver, Colorado. It would be
9 difficult to say which of these studies are the most important ones, because each study
10 focuses on a particular hypothesis, and the range of possible investigations is immense.
11 Some of the most important work was done under the auspices of the NIEHS, “EMF
12 RAPID” program that funded laboratory research to determine what, if any, aspects of EMF
13 interaction with biological systems had the potential to express themselves as adverse disease
14 outcomes. The conclusion of this research program was summarized by NIEHS in 1999 as
15 follows:⁴

16 *“The scientific evidence suggesting that ELF-EMF exposures pose*
17 *any health risk is weak. [...] No indication of increase leukemias in*
18 *experimental animals has been observed. [...] Virtually all of the*
19 *laboratory evidence in animals and humans, and most of the*
20 *mechanistic studies in cells fail to support a causal relationship*
21 *between exposure to ELF-EMF at environmental levels and changes*
22 *in biological function or disease status.” (p. ii of Executive*
23 *Summary)*

³ Ahlbom A.; Cardis E.; Green A.; Linet M.; Savitz D.; Swerdlow A.; *Review of the Epidemiologic Literature on EMF and Health*, Environ Health Perspect 109 (Suppl 6):911-33 (2001).

⁴ National Institutes of Environmental Health Sciences (NIEHS), *Health Effects From Exposure to Power-Line Frequency Electric and Magnetic Fields*, NIH# 99-4493 (1999). Research Triangle Park, NC.

1 Despite the lack of supporting laboratory evidence for EMF effects,^{5,6} epidemiologic
2 analyses have continued in recent years, and the following list of prominent reviews and
3 analyses provides the conclusions of 8 commentaries on and meta-analyses of the
4 epidemiologic literature, which have been released within the past three years:

- 5 1. Albom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, et al, *A*
6 *Pooled Analysis of Magnetic Fields and Childhood Leukaemia.*, Br. J. Cancer
7 83 :692-8 (2000).

8
9 *“When the authors pooled nine epidemiology studies that*
10 *included long-term measurements of magnetic fields, they*
11 *found a relative risk of 2.0 (1.27-3.13) for childhood*
12 *leukaemia in the children with average exposures of 4 mG or*
13 *greater. For children with lower average exposures, no*
14 *significant elevation of childhood leukemia was found in the*
15 *pooled studies. The authors state that “The explanation for*
16 *the elevated risk is unknown, but selection bias may have*
17 *accounted for some of the increase.”*

- 18
19 2. California Department of Health Services (“CADHS”), *An Evaluation of the*
20 *Possible Risks From Electric and Magnetic Fields (EMF) From Power Lines,*
21 *Internal Wiring, Electrical Occupations and Appliances,* California EMF
22 Program, 1515 Clay Street, 17th Floor, Oakland, CA 94612 (2002).
23 (Available: <http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html>):

5 Boorman G.A., McCormick D.L.; Findlay J.C.; Hailey J.R.; Gauger J.R.; Johnson T.R.; et al.,
Chronic Toxicity Oncogenicity Evaluation of 60 Hz (Power Frequency) Magnetic Fields in
F344/N Rats, Toxicol Pathol 27:267-78 (1999).

6 McCormick D.L.; Boorman G.A.; Findlay J.C.; Hailey J.R.; Johnson T.R.; Gauger J.R., et al.
Chronic Toxicity/Oncogenicity Evaluation of 60 Hz (Power Frequency) Magnetic Fields in
B6C3F1 Mice, Toxicol Pathol 27:279-85 (1999).

1 *“Three epidemiologists who worked for the California*
2 *Department of Health Services (DHS) reviewed studies about*
3 *possible health problems from electric and magnetic fields*
4 *(EMFs) [...] To one degree or another, all three of the DHS*
5 *scientists were inclined to believe that EMFs can cause some*
6 *degree of increased risk of childhood leukemia, adult brain*
7 *cancer, Lou Gehrig's Disease [ALS], and miscarriage.”*
8

- 9 3. Greenland Sheppard A.R., Kaune W.T., Poole C, Kelsh M.A., *A Pooled*
10 *Analysis of Magnetic Fields, Wire Codes, and Childhood Leukemia,*
11 *Childhood Leukemia-EMF Study Group, Epidemiol 11:624-634 (2000):*

12
13 *“Upon pooling 15 epidemiology studies of childhood leukemia, the*
14 *authors found evidence of increased risk at the low, but upper-end*
15 *magnetic field levels to which a small proportion of United States*
16 *residents are exposed. The authors estimated a relative risk (RR) of*
17 *1.7 (1.2 - 2.3) for exposures above 3 mG, and a population*
18 *attributable fraction of 3% (-2% - +8%) for exposures above 0.5*
19 *mG.”*
20

- 21 4. Hatch E.E., Kleinerman R.A., Linet M.S., Tarone R.E., Kaune W.T.,
22 Auvinen A., et al., *Do Confounding or Selection Factors of Residential*
23 *Wiring Codes and Magnetic Fields Distort Findings of Electromagnetic*
24 *Fields Studies?*, Epidemiol 11:189-98 (2000):

25
26 *“In contrast with several previous studies, our recent large*
27 *case-control study found little association between childhood acute*
28 *lymphoblastic leukemia (ALL) and electric-power-line wire codes.”*
29

- 30 5. Kleinerman R.A., Kaune W.T., Hatch E.E., Wacholder S., Linet M.S.,
31 Robison L.L., Niwa S., Tarone R.E., *Are Children Living Near High-Voltage*
32 *Power Lines at Increased Risk of Acute Lymphoblastic Leukemia?*, Am. J.
33 Epidemiol. 151:512-5 (2000):

1 *“The authors analyzed distance to transmission and*
2 *three-phase primary distribution lines within 40 m of homes*
3 *and created an exposure index of distance and strength of*
4 *multiple power lines (408 case-control pairs). Neither*
5 *distance nor exposure index was related to risk of childhood*
6 *acute lymphoblastic leukemia, although both were associated*
7 *with in-home magnetic field measurements. Residence near*
8 *high-voltage lines did not increase risk.”*
9

- 10 6. Skinner J., Mee T.J., Blackwell R.P., Maslanyj M.P., Simpson J., Allen S.G.,
11 Day N.E., Cheng K.K., Gilman E., Williams D., Cartwright R., Craft A.,
12 Birch J.M., Eden O.B., McKinney P.A., Deacon J., Peto J., et al., *Exposure*
13 *to Power Frequency Electric Fields and the Risk of Childhood Cancer in the*
14 *UK, Brit. J. Cancer 87:1257-66 (2002):*

15
16 *“The United Kingdom Childhood Cancer Study, a*
17 *population-based case-control study covering the whole of*
18 *Great Britain, incorporated a pilot study measuring electric*
19 *fields. [...] With exposure modeled as a continuous variable,*
20 *odds ratios for an increase in the principal metric of 10 V/m*
21 *were close to unity for all disease categories, never differing*
22 *significantly from one.”*
23

- 24 7. *UK Childhood Cancer Study Investigators, Childhood Cancer and*
25 *Residential Proximity to Power Lines, Brit. J. Cancer. 83:1573-1580 (2000):*

26
27 *“Our results provide no evidence that proximity to electricity*
28 *supply equipment or exposure to magnetic fields associated*
29 *with such equipment is associated with an increased risk for*
30 *the development of childhood leukemia nor any other*
31 *childhood cancer.”*
32

- 1 8. Wartenberg D., *Residential EMF Exposure and Childhood Leukemia:*
2 *Meta-Analysis and Population Attributable Risk*, Bioelectromagnetics, Suppl.
3 5: S86-104 (2001):

4
5 *“This paper reports on 18 studies of childhood leukemia and*
6 *exposure to magnetic fields, of which only one was not a*
7 *case-control study. Thus all of the biases associated with*
8 *case-control studies may be present. [...] The studies of*
9 *residential magnetic field exposure and childhood cancer*
10 *have many possible sources of bias. Unfortunately, these are*
11 *very hard to quantify, unless we systematically analyze all the*
12 *data, which are generally not available. [...] It seems unlikely*
13 *that selection bias cannot be the sole explanation of the*
14 *reported associations between exposure to magnetic fields*
15 *and childhood cancer incidence.”*
16

17 Q8. Why are there differences among the various reviews and studies?

18 A8. There are several possible reasons for the differences among the various reviews and studies.
19 Some scientists put more emphasis on the statistical associations while others question why
20 animal and test tube experiments have been unable to identify an EMF mechanism or a
21 specific health problem. The absence of support from such laboratory studies causes many
22 scientists to distrust epidemiological evidence from statistical studies in human populations.
23 Others have more faith in the quality of the epidemiological studies in human populations
24 and hence give more credence to them, because extrapolations from animal species or from
25 laboratory test-tube systems need not be made.

26
27 Q9. What conclusions have been drawn from the laboratory and animal studies of EMF
28 biological effects?

29 A9. Supporting evidence for an effect of EMF exposure on health has not been forthcoming from
30 laboratory animals exposed to EMF, or from mechanistic analysis of how EMF might cause
31 an effect on living cells. To date, there is neither an accepted mechanism by which power

1 line EMF can cause disease, nor is there any animal model in which exposure to even
2 considerably elevated 60-Hz magnetic fields has consistently produced a disease or a
3 pre-disease condition. This means that no one has been able to identify what aspect of EMF
4 is the one we should potentially avoid. If adverse health effects are to be expected, would
5 they be due specifically to the frequency of oscillation, the electric fields, the magnetic fields,
6 continuous exposure, intermittent exposure, peak fields, transients? In spite of many years
7 of work, no firm evidence of adverse EMF effects has been found in the laboratory for any
8 of the measures of EMF exposure that have been examined.

9
10 Q10. What is the present status of expert opinion on EMF health effects?

11 A10. At this point in time, a large volume of literature on the question of EMF health effects has
12 been generated, representing the accumulation of many years of laboratory work and many
13 years of human experience with EMF. The scientific data on EMF and health have been
14 assembled and reviewed by many independent consensus groups of research and health
15 scientists. These groups and agencies include the World Health Organization, the National
16 Radiation Protection Board (UK), the National Academy of Sciences, the American Medical
17 Association, the American Physical Society (the professional society for American
18 physicists), the American Cancer Society, the Swedish National Health and Welfare Board,
19 and others. These “blue-ribbon” panels do not identify EMF from any type of electric-power
20 transmission line as unsafe for nearby residents and public. The reports of these groups are
21 voluminous, thorough, and even-handed. Some of the conclusions are given below:

22
23 American Cancer Society (“ACS”), *What are the Risk Factors for leukaemia? Environmental*
24 *Risk Factors: Electromagnetic Field Exposure*, (2002) (available on the Internet at:
25 www.cancer.org/docroot/PED/content/PED_1_3X_Radiation_Exposure_and_Cancer.asp?
26 [www.cancer.org/docroot/CRI/content/CRI_2_4_2X_What_are_the_risk_factors_for_leuk](http://www.cancer.org/docroot/CRI/content/CRI_2_4_2X_What_are_the_risk_factors_for_leukemia_24.asp?)
27 [emia_24.asp?](http://www.cancer.org/docroot/CRI/content/CRI_2_4_2X_What_are_the_risk_factors_for_leukemia_24.asp?)

1 www.cancer.org/docroot/PED/content/PED_1_3X_Unproven_Risks.asp?:

2 *“The majority of studies published so far suggest either no increased risk or*
3 *a very slightly increased risk. The vast majority of cases of leukaemia are*
4 *clearly not related to EMF exposure.” “Non-ionizing radiation:*
5 *Electromagnetic radiation at frequencies below ionizing and ultraviolet*
6 *levels has not been proven to cause cancer. Some studies suggest an*
7 *association with cancer, but most of the now-extensive research in this area*
8 *does not.”*
9

10 American Conference of Governmental Industrial Hygienists (“ACGIH”), *Threshold Limit*
11 *Values (TLVs) and Biological Exposure Indices (BEIs)*, ACGIH 6500 Glenway Ave.,
12 Cincinnati, OH. pp. 142-146 (2002):

13 *“It is recommended that, lacking specific information on electromagnetic*
14 *interference from the manufacturer, the exposure of persons wearing cardiac*
15 *pacemakers or similar medical electronic devices be maintained at or below*
16 *1,000mG at power-line frequencies (60 Hz).”*
17

18 European Union (EU), *Scientific Committee on Toxicity, Ecotoxicity and the Environment*
19 *(CSTEE): Opinion on Possible Effects of Electromagnetic Fields (EMF), Radio Frequency*
20 *Fields (RF) and Microwave Radiation on Human Health*, EUROPEAN COMMISSION
21 DIRECTORATE-GENERAL: HEALTH AND CONSUMER PROTECTION (2001),
22 Brussels, C2/JCD/csteeop/EMF/RFF30102001/D(01).

23 (available at: http://europa.eu.int/comm/food/fs/sc/sct/out128_en.pdf):

24 *“Combined analyses of the epidemiological studies on the association*
25 *between exposure to ELF and childhood leukaemia have strengthened the*
26 *evidence of an association. However, given some inconsistencies in exposure*
27 *measurements and the absence of other criteria commonly used in assessing*
28 *causality (particularly a plausible explanation of underlying biological*
29 *mechanisms, see above), the association does not meet adequate criteria for*
30 *being considered causal. There is no convincing suggestion of any other*
31 *carcinogenic effect of ELF on either children or adults.” (p. 10)*
32

1 Institute of Electrical & Electronics Engineers (“IEEE”), *C95.6-2002 IEEE Standard for*
2 *Safety Levels with Respect to Human Exposure to Electromagnetic Fields 0 to 3 kHz.*
3 *Prepared by Subcommittee 3, Safety Levels with Respect to Human Exposure, 0 to 3 kHz, of*
4 *the International Committee on Electromagnetic Safety, Standards Coordinating Committee*
5 28. IEEE, Inc., Three Park Avenue, New York, NY 10016-5997, USA. ISBN 0-7381-3389-2
6 (2002):

7 “Protection is to be afforded to individuals in the general population by
8 limiting maximum permissible exposure (MPE) to magnetic field levels of
9 9,040 mG at 60-Hz power-line frequencies.”
10

11 International Agency for Research on Cancer (“IARC”), *Non-Ionizing Radiation, Part 1:*
12 *Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields. IARC*
13 *Monographs on the Evaluation of Carcinogenic Risks in Humans, 80:1-429 (2002):*

14 “The association between childhood leukaemia and high levels of magnetic
15 fields is unlikely to be due to chance, but it may be affected by bias. In
16 particular, selection bias may account for part of the association.” (p. 332)
17 [Thus] there is limited evidence in humans for the carcinogenicity of
18 extremely low-frequency magnetic fields in relation to childhood leukaemia.
19 There is inadequate evidence in humans for the carcinogenicity of extremely
20 low-frequency magnetic fields in relation to all other cancers.” (p. 338)
21

22 International Commission on Non-Ionizing Radiation Protection (“ICNIRP”). *Guidelines*
23 *for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields,*
24 *Health Physics 74:494-522 (1999) (available at:*

25 <http://www.icnirp.de/documents/emfgdl.pdf>):

26 “The main objective of [ICNIRP] is to establish guidelines for limiting EMF
27 exposure that will provide protection against known adverse health effects.
28 An adverse health effect causes detectable impairment of the health of the
29 exposed individual or of his or her offspring; a biological effect, on the other
30 hand, may or may not result in an adverse health effect. [ICNIRP Reference
31 Levels protect the general public from established health effects due to EMF
32 exposure. The Reference Levels for 60-Hz EMF exposure are: 4.16 kV/m and
33 833 mG.]”

1
2 Minnesota Department of Health (“MDH”) *A White Paper on Electric and Magnetic Field*
3 *(EMF) Policy and Mitigation Options Prepared by the Minnesota State Interagency*
4 *Working Group on EMF Issues*, September 2002 (available at:

5 <http://www.health.state.mn.us/divs/eh/radiation/emf/emfrept.pdf>):

6 *“The Minnesota Department of Health (MDH) concludes that the current*
7 *body of evidence is insufficient to establish a cause and effect relationship*
8 *between EMF and adverse health effects.”*
9

10 National Academy of Sciences (“NAS”); National Research Council (“NRC”), *Research on*
11 *Power-Frequency Fields Completed Under the Energy Policy Act of 1992. Final Report.*

12 National Academy of Sciences Evaluation of the EMF RAPID Program, National Research
13 Council, National Academy Press, June 1999, 107 pp. (available at:

14 <http://www.nap.edu/catalog/9587.html>):

15 *“Results of the EMF-RAPID program do not support the contention that the*
16 *use of electricity poses a major unrecognized public-health danger.”*
17

18 National Radiation Protection Board (“NRPB”) of the United Kingdom (UK), *ELF*
19 *Electromagnetic Fields and the Risk of Cancer: Documents of the NRPB, Vol. 12, No. 1.*

20 (2001)

21 (available at: http://www.nrpb.org/publications/documents_of_nrpb/pdfs/doc_12_1.pdf)

22 *“Laboratory experiments have provided no good evidence that extremely low*
23 *frequency electromagnetic fields are capable of producing cancer, nor do*
24 *human epidemiological studies suggest that they cause cancer in general.*
25 *There is, however, some epidemiological evidence that prolonged exposure*
26 *to higher levels of power frequency magnetic fields is associated with a small*
27 *risk of leukaemia in children. In the absence of clear evidence of a*
28 *carcinogenic effect in adults, or of a plausible explanation from experiments*
29 *on animals or isolated cells, the epidemiological evidence is currently not*
30 *strong enough to justify a firm conclusion that such fields cause leukaemia*
31 *in children.”*
32

1 Netherlands Health Council, Exposure to Electromagnetic Fields (0 Hz - 10 MHz). The
2 Minister of Housing, Spatial Planning and the Environment, Report Number:
3 U-629/EvR/RA/559-C, The Hague, the Netherlands, 7 March 2000, (available at:
4 <http://www.gr.nl/pdf.php?ID=25>):

5 *“The results of epidemiological studies [of EM field exposure], both in*
6 *children and adults, do not allow the establishment of a causal relationship*
7 *between the observed [diseases] and exposure to ELF EM fields or any other*
8 *factor. Also the large body of experimental research has failed to produce*
9 *any evidence of a causal relationship between exposure to ELF EM fields*
10 *and the occurrence of any form of cancer. Effects of EMF in the general*
11 *population [can be avoided] by limiting whole-body exposure to 1,200 mG*
12 *at 50 Hz power-line frequencies.”*
13

14 World Health Organization (“WHO”), *Electromagnetic Fields and Public Health:*
15 *Extremely Low Frequency Fields and Cancer. Fact Sheet No. 263, October 2001.* (available
16 at: http://www.who.int/docstore/peh-emf/publications/facts_press/efact/efs263.html)

17 *“While the classification of ELF magnetic fields as possibly carcinogenic to*
18 *humans [by IARC] has been made, it remains possible that there are other*
19 *explanations for the observed association between exposure to ELF magnetic*
20 *fields and childhood leukaemia. In particular, issues of selection bias in the*
21 *epidemiological studies and exposure to other field types deserve to be*
22 *rigorously examined and will likely require new studies.”*
23

24 Q11. Are you aware of whether any state, national, or world health organizations or regulatory
25 bodies have adopted or recommended guidelines that limit EMF exposure fields from electric
26 power lines or other sources?

27 A11. The U.S. has no federal standards limiting occupational or residential exposure to 60-Hz
28 EMF. The first of the two tables below shows guidelines suggested by national and world
29 health organizations. The second table shows guidelines that have been adopted by various
30 States in the U.S. The first Table shows the public-health-based levels, which are intended
31 to be protective against adverse health effects, but should not be viewed as demarcation lines
32 between safe and dangerous levels of EMF. The latter (State) guidelines have been designed

1 to maintain the status quo of EMF on and near transmission-line right-of-ways, and are not
 2 health based.

60-Hz EMF Guidelines Established by Safety Organizations		
Organization	Magnetic Field (B)	Electric Field (E)
American Conference of Governmental and Industrial Hygienists (“ACGIH”) (occupational)	10,000 mG ^(a)	25 kV/m
	1,000 mG ^(b)	1 kV/m
International Commission on Non-Ionizing Radiation Protection (“ICNIRP”) (general public, continuous exposure)	833 mG	4.2 kV/m
Institute of Electrical and Electronics Engineers (“IEEE”) Standard C95.6 (general public, continuous exposure)	9,040 mG	5.0 kV/m
U.K. National Radiological Protection Board (“NRPB”) [adopted the ICNIRP guidelines]	833 mG	4.2 kV/m
Comparison to <u>steady</u> EMF that are encountered in non-power line settings:		
[Earth’s magnetic field, and atmospheric electric fields, static levels, typical of environmental exposure ^(c)]	[550 mG]	[0.2 kV/m to 1.5 kV/m]
[Magnetic Resonance Imaging Scan, magnetic field intensity ^(c)]	[20,000,000 mG]	----

3 On the ACGIH levels, ^(a) represents guidelines for the general worker, and ^(b) represents a
 4 guideline for workers with cardiac pacemakers.

1 (c) These EMF are steady fields, and do not vary in time at the characteristic 60-cycles-per-
 2 second that power-line fields do. However, if a person moves in the presence of these fields,
 3 the body experiences a time-varying field.

State Transmission-Line 60-Hz EMF Standards and Guidelines				
State / Line Voltage	Electric Field (E)		Magnetic Field (B)	
	On R.O.W.	Edge R.O.W.	On R.O.W.	Edge R.O.W.
< 230 kV	8 kV/m	2 kV/m		150 mG ^c
Florida 230-500 kV	10 kV/m			200 mG ^c
>500 kV				250 mG ^c
Minnesota	8 kV/m			
Montana	7 kV/m ^a	1 kV/m ^b		
New Jersey		3 kV/m		
New York	11.8 kV/m 11.0 kV/m ^d 7.0 kV/m ^a	1.6 kV/m		200 mG ^c
Oregon				

Key: ROW = right-of-way; mG = milligauss; kV/m = kilovolts per meter

Notes:

- ^a Maximum for highway crossings
- ^b May be waived by the landowner
- ^c Maximum-load magnetic fields
- ^d Maximum for private road crossings

Source: Questions and Answers About EMF. National Institute of Environmental Health Sciences and U.S. Department of Energy, 2002.

1 **4. Summary of the EMFs Calculated for the Project**

2 Q12. How did you assess the EMF impact of the proposed Project?

3 A12. I relied upon the EMF modeling performed by Mr. Jeff Carrara, a Systems Engineer for
4 VELCO.

5
6 Q13. What information did you and Mr. Carrara exchange?

7 A13. Mr. Carrara provided to me information on the type of computer model he used, the input
8 parameters, and the results for electric and magnetic fields as a function of distance from the
9 lines, and under various loading assumptions.

10
11 Q14. Are you comfortable that Mr. Carrara utilized an appropriate computer model and input
12 assumptions?

13 A14. Yes. I reviewed all of this data and then posed questions to Mr. Carrara on points that
14 required clarification. Based upon my review, I am confident that the EMF modeling results
15 reflect accurate calculations of EMFs along the existing and future line corridors.

16
17 Q15. Please summarize the results of the EMF calculations.

18 A15. The following tables compare the existing conditions (2003) with the predictions for future
19 years (2006, 2009, 2012), should the Project be built. The West Rutland to New Haven
20 corridor currently has a 115-kV line, and a 345-kV line (35.5 miles) will be added to this
21 corridor. The New Haven to Queen City corridor currently has a sub-transmission line
22 (46kV between New Haven and Vergennes and 34kV from Vergennes to Queen City), which
23 will be replaced by a 115-kV line (27.1 miles). The New Haven to Queen City corridor will
24 be 100 feet wide in most locations. The West Rutland to New Haven corridor ranges from
25 250 feet to 350 feet wide. For the EMF predictions, we used a 100 ft. ROW width for the
26 New Haven to Queen City corridor, and a 250 ft. ROW width for the West Rutland to New
27 Haven corridor.

1 For modeling EMFs, the lines were placed within the corridor at the planned
 2 locations. The calculations were performed for locations where the lines make their closest
 3 approach to ground level. E_{max} and $E_{ROW\ edge}$ designate the electric field maximum within the
 4 ROW and at the edge of the ROW, respectively. These (the electric fields) do not change
 5 with current loads. B_{max} and $B_{ROW\ edge}$ designate the magnetic field maximum within the
 6 ROW and at the edge of the ROW, respectively. Magnetic field values do change depending
 7 on current (power) carried by the lines. Thus, both the annual average loads and annual peak
 8 loads were calculated for the existing and future years.

Year	Load Conditions	New Haven to Queen City (proposed) 115 kV corridor **			
		E_{max} (kV/m)	B_{max} (mG)	$E_{ROW\ edge}$ (kV/m)	$B_{ROW\ edge}$ (mG)
2003	Annual average	0.290	13.9	0.110	3.2
	Annual peak	0.290	21.3	0.110	4.9
2006	Annual average	1.150	14.8	0.240	3.6
	Annual peak	1.150	22.8	0.240	5.5
2009	Annual average	1.150	18.8	0.240	4.6
	Annual peak	1.150	28.9	0.240	7.0
2012	Annual average	1.150	21.5	0.240	5.1
	Annual peak	1.150	33.1	0.240	7.9

Year	Load Conditions	West Rutland to New Haven (proposed) 115 kV & 345 kV corridor			
		E _{max} (kV/m)	B _{max} (mG)	E _{ROW edge} (kV/m)	B _{ROW edge} (mG)
2003	Annual average	1.150	56.4	0.200	8.2
	Annual peak	1.150	86.8	0.200	12.6
2006	Annual average	6.840	30.4	0.830	3.3
	Annual peak	6.840	46.8	0.830	5.0
2009	Annual average	6.840	36.6	0.830	4.0
	Annual peak	6.840	56.5	0.830	6.2
2012	Annual average	6.840	41.0	0.830	4.5
	Annual peak	6.840	63.1	0.830	6.9

1 ** For about ½ mile of the northernmost section of the proposed New Haven to Queen City
 2 115-kV line, the 115 kV line from Williston to Queen City joins the right-of-way. The
 3 following table applies to EMFs for this short, northernmost section.

Year	Load Conditions	Northernmost ½ mile of New Haven to Queen City ROW			
		E _{max} (kV/m)	B _{max} (mG)	E _{ROW edge} (kV/m)	B _{ROW edge} (mG)
2003	Annual average	1.156	38.2	0.310	8.0
	Annual peak	1.156	58.5	0.310	12.3
2006	Annual average	1.770	30.4	0.338	5.9
	Annual peak	1.770	46.8	0.338	9.1
2009	Annual average	1.770	32.2	0.338	6.6
	Annual peak	1.770	49.5	0.338	10.1
2012	Annual average	1.770	35.3	0.338	7.6
	Annual peak	1.770	54.3	0.338	11.7

4 Q16. Please explain what conclusions on EMF levels you draw from these results.

1 A16. Several conclusions about EMF impact can be drawn from these results. First, in comparison
2 to the international, national and state standards and guidelines listed earlier, the EMF levels
3 (both the maximum levels and at the right-of-way edge) are considerably below what is
4 permissible by the guidelines. Moreover, in terms of the magnetic fields, which are the
5 component of EMF that has been subject to the greatest scrutiny, the increment caused by
6 the Project is either very modest or, in fact, in a direction that reduces the magnetic field
7 impact.

8
9 Q17. What are your conclusions with regard to impact of the Project EMF's on public health?

10 A17. On the basis of the EMF levels at issue and on the basis of the scientific literature and public
11 health guidance available in this area, I conclude that the EMF that will be produced as a
12 result of this Project will not have adverse public health effects.

13
14 **5. Summary of Analysis and Conclusions**

15 Q18. What is your summary of the current status of the science of EMF health effects?

16 A18. Thousands of studies have now examined the hypothesis that power-line EMF exposure can
17 lead to biological effects, and potentially, adverse health impacts. Out of this vast number,
18 some studies have reported results that can be interpreted as suggestive of power-line EMF
19 being hazardous to human health. However, it has not been possible to determine if these
20 results truly reflect a consistent and causal role for EMF, or whether they represent statistical
21 and non-causal fluctuations, such as would be expected in repeated investigations. Many
22 studies that have tried, but failed, to replicate such results support the conclusion that EMF
23 is not hazardous, but the overall summary is that evidence for EMFs harming health is weak
24 and inconsistent. Even more scarce is evidence as to what aspects or types of EMF exposure,
25 if any, are to be implicated in the health-risk associations. No biological process by which
26 EMF may plausibly cause harm to health that is consistent with known scientific phenomena
27 has been established. As a consequence, research to date cannot give policy-makers

1 confidence as to the extent to which, if at all, societal resources should be expended to reduce
2 EMF exposures.

3
4 Q19. Some researchers have proposed that policy makers adopt strategies of “prudent avoidance”
5 of EMF exposure. What is your opinion of such proposals?

6 A19. Even if a strategy such as “prudent avoidance” or “the precautionary principle” were to be
7 considered, policymakers are not able to specify what aspect of EMF should be “prudently
8 avoided” or “pre-cautiously regulated.” It is easy enough to recommend that people move
9 analog electric clocks away from their beds, for example, and there is likely little harm in
10 recommending that utilities consider no-cost or trivial-cost EMF mitigation measures. The
11 majority of researchers, however, would say that extensive expenditures on EMF mitigation
12 cannot be well-justified or guided by science.

13 Generally, the assumption has been made that the intensity of time-averaged, 60-Hz
14 magnetic fields should be the focus of mitigation. However, no scientific basis for this
15 choice exists, and many other specific aspects of the “EMF environment” have been
16 proposed as possible agents of biological activity, including: (1) Electric field intensity, (2)
17 Magnetic fields with an intensity within a certain “window” of possible amplitudes, (3) Peak
18 magnetic fields, (4) 60-Hz magnetic fields with time-varying frequency, (5) Magnetic fields
19 at harmonic frequencies (180 Hz, 300 Hz, *etc.*), (6) Only the power-line magnetic field that
20 is parallel to the earth’s static magnetic field, (7) Only magnetic fields of non-steady, or
21 “intermittent” amplitude, (8) Magnetic fields with circular polarization, *i.e.*, rotating
22 magnetic fields), (9) Magnetic fields of frequencies in “resonance” with certain biological
23 ions such as calcium (Ca^{++}), sodium (Na^+), or potassium (K^+), (10) night-time magnetic
24 fields that may interfere with melatonin secretion.⁷ None of these aspects of EMFs,
25 however, has been convincingly shown to be a likely risk factor, and thus there is no basis

⁷ Valberg, P.A. *Designing EMF Experiments: What is Required to Characterize “EMF Exposure,”*
Bioelectromagnetics 16:396-401 (1995).

1 for committing significant resources to the development or implementation of avoidance
2 strategies when it is not known what is to be avoided. Thus, the state of the science suggests
3 that anxiety, time, energy, and money that might be spent mitigating power-line EMF would
4 likely provide much greater health benefit if it were expended on non-EMF health concerns.
5 Other health-improvement activities are much more likely to produce a health benefit,
6 including improved home safety, improved vehicle safety, improved pre-natal care, better
7 nutrition, more exercise, more frequent health checkups, encouragement of smoking
8 cessation, drinking in moderation, weight reduction, blood pressure reduction, cholesterol
9 reduction, and so forth.

10 Policymakers also need to consider that measures taken to reduce a hypothetical risk
11 may lead to an increase in other, real risks. For example, EMFs from a transmission line can
12 be reduced by moving the phase conductors closer together, but this increases the risk of
13 failure by flashover, and can make the tasks of electric-utility maintenance workers more
14 hazardous. Likewise, underground lines may reduce EMFs in some areas, but this
15 mitigation of hypothetical risk needs to be weighed against the ecological damage done to
16 wetlands and wildlife habitat by the excavation necessary for underground lines.

17 In the final analysis, no human endeavor is without risk. Regardless of how many
18 times one finds a safe outcome for any phenomenon, one cannot guarantee that the next
19 investigation will not yield an adverse effect. This is an example of the fact that it is
20 impossible to prove a negative. Even though it not possible to provide proof that power-line
21 EMFs carry no significant risk to human health, it is my belief that the EMF that will be
22 produced as a result of this Project will not have adverse public health effects. Moreover,
23 I can say with confidence that the transmission-line improvements that VELCO proposes to
24 make in this Project will, in general, result in reductions of magnetic field strengths along
25 most of the affected rights-of-way under most system conditions, compared to the fields that
26 are produced today, or would be produced in the future if the existing transmission lines were
27 to continue to provide electric power to the northwestern region of Vermont.

- 1 Q20. Does this conclude your testimony.
- 2 A20. Yes, it does.

EXHIBITS LIST
Peter Valberg

- | | |
|---------------------|---|
| VELCO Exhibit PAV-1 | Resume of Peter Alexis Valberg |
| VELCO Exhibit PAV-2 | Chart Regarding Testimony Before Regulatory Boards on the Issue of EMF Health Effects |