

## **8. ELECTRICAL EFFECTS**

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### **8.1 INTRODUCTION**

This section describes the possible effects from exposure to electric and magnetic fields (EMF) associated with the construction and operation of the Miguel–Mission 230kV #2 Project.

EMFs are present wherever electricity flows—around appliances and transmission lines, in offices, schools, and homes. Electric fields are invisible lines of force created by voltage and shielded by most materials. Magnetic fields are invisible lines of force, created by electric current, and not shielded by most materials. These fields are low energy, extremely low frequency, and should not be confused with high energy or ionizing radiation, such as X-rays and gamma rays.

Some studies have reported a weak association between estimates of residential magnetic field exposure and certain types of childhood cancer. These studies have not shown that the magnetic fields from powerlines actually cause cancer. Some studies on workers have also found associations between estimates of EMF exposure and some forms of cancer, but these results have been very inconsistent. Laboratory experiments have shown that exposure levels typically well above those normally found in residences can produce changes in cells, but there is little or no evidence that these changes could constitute a health risk.

### **8.2 BACKGROUND**

The transport of electricity is described in terms of both its voltage and current flow. Using these terms, the transport of electricity is analogous to the flow of water through a pipe. The pressure driving the water is the counterpart to the voltage on the powerline, and the amount of water flowing in the pipe is the counterpart to the amount of electric current on the line.

Electrical lines and equipment produce an electric field as a result of the voltage applied to their wiring. The strength of the electric field is expressed in volts per meter (V/m) or kilovolts per meter (kV/m). The electric field strength falls off sharply with distance. Objects such as houses or trees shield electric fields. Thus, even in proximity to powerlines or substations, the electric field in nearby residences is largely a result of internal sources; external sources of electric fields are effectively shielded from indoor environments.

The flow of current in electrical lines and equipment produces a magnetic field. The strength of the magnetic field is measured in units called Gauss (G). Because this unit is much too large for expressing magnetic field intensities encountered in daily life, most often magnetic field intensities are expressed in milligauss (mG), which is one one-thousandth of a Gauss. The field intensity varies with the amount of current flow. Like electric fields, the intensity of a magnetic field decreases as distance from the source increases. But unlike electric fields, magnetic fields are not shielded by buildings, trees, and most other objects.

Electrical transmission and distribution systems are not the only sources of magnetic fields. Within homes and workplaces, local sources of magnetic fields include building wiring and

plumbing, electric blankets, electric stoves, computer terminals, bedside clocks, ceiling fans, and other appliances that people may use for prolonged periods. Indeed, some of the common sources of higher magnetic fields are appliances and electrical devices found within the home. The magnetic field levels from such sources in typical use can range up to thousands of mG or higher; however, the duration of exposure from many appliances is typically much shorter than that from other sources. Thus, exposure to both electric and magnetic fields occurs continuously, and is not simply a function of living or working near a powerline or facility. Exposure depends upon the many sources and field strengths present where a person lives, works, or otherwise spends time.

### **8.2.1 History**

In the late 1960s and early 1970s, the possibility of adverse health effects resulting from exposures to electric fields received considerable attention. This attention was motivated by reports from the Soviet Union of various health complaints among utility workers in high-voltage switchyards. Subsequent research on electrical utility workers in Europe and North America failed to confirm the complaints; Soviet investigators later indicated that their concerns had been “overstated.”

In the 1980s, interest shifted primarily to magnetic fields for two major reasons. First, Wertheimer and Leeper in 1979<sup>1</sup> published a paper reporting a statistical association between childhood cancer and the apparent current-carrying capacity of the powerlines near the study residences. Second, it was recognized that exposure to electric fields from outside sources is limited because of effective shielding by building materials. This was confirmed in studies that failed to find associations between the capacity of outside powerlines and electric field levels within homes. The shift away from electric fields has been further justified by subsequent residential studies that fail to report an association between measured electric fields and cancer in either children or adults.<sup>2</sup>

## **8.3 CURRENT RESEARCH**

To assess potential health risks from an environmental agent such as power frequency EMF, interdisciplinary groups of scientists must consider the results from epidemiological investigations and laboratory studies on animals, tissues, and cells.

### **8.3.1 Epidemiology**

Epidemiology investigates the patterns and potential causes of disease within human populations. The objective of epidemiology is to evaluate and measure the associations between exposures to environmental factors (e.g., asbestos, benzene) and health outcomes (e.g., lung disease, leukaemia). Epidemiological studies look for associations between the exposure of a group of people to an agent (possible risk factor) and the occurrence of disease in that group. Epidemiology deals with people in their natural environment, so exposures cannot be controlled or limited to the factors being studied. Thus, epidemiology addresses associations with disease outcomes; it does not establish whether a particular agent causes disease.

Some documented epidemiological studies conducted in community settings have reported weak associations between childhood cancer and estimates of exposure to magnetic fields. Other epidemiological studies, equally well designed and conducted, have reported no associations between proximity to powerline sources of magnetic fields and cancer. Those studies reporting associations are not consistent with respect to cancer type. Two recent pooled analyses, which combined data from multiple studies, reported a leukemia association for measured fields above 3 or 4 mG, but found little or no association with so-called "wire codes" (proximity and capacity of nearby powerlines). In earlier individual studies, the opposite pattern seemed to predominate: "wire codes" showed a significant association while measured fields did not.

Exposure assessment is a universal deficiency in the epidemiological literature. The ability of surrogate measures, such as proximity and current-carrying capacity of powerlines, to predict power-frequency magnetic field exposures is quite limited. Improved methodology in recent studies has failed to show a commensurate strengthening of the evidence relating to health risks. In the occupational setting, some studies have reported weak associations between work in electrical occupations and leukemia or brain cancer, but other studies have not.

### **8.3.2 Laboratory Studies**

A wide range of magnetic field intensities at extremely low frequencies (ELF) has been studied in the laboratory to attempt to elicit biological responses and identify the conditions and mechanisms under which they can be produced. No accepted biophysical mechanism currently exists that can explain readily how a cell could respond to low intensity, low frequency magnetic fields. Any imposed external electric and magnetic fields must compete with fundamental physical fluctuations (e.g., thermal noise) and endogenous background biological fields (e.g., those generated by the normal activity of the heart, brain, skeletal muscle, and smooth muscle in the gut and airways). Most laboratory studies have involved exposures hundreds to thousands of times higher than those typically found in residential backgrounds and some occupational settings. From several thousand studies in the literature, relatively few biological responses are confirmed to occur with exposure to time-varying magnetic fields at intensities less than 1,000 mG, and those that have been confirmed have not been linked clearly to adverse health effects. Although there is considerable interest in determining whether any biological basis exists for a cause-and-effect relationship between power frequency fields and cancer, the available laboratory data have not provided substantive support for this hypothesis.

### **8.3.3 Conclusions**

Numerous internationally recognized scientific organizations and independent regulatory advisory groups have conducted scientific reviews of the EMF research literature.<sup>3</sup> Their ability to bring together experts from a variety of disciplines to review the full body of research on this complex issue gives their reports credibility. Without exception, these major reviews have reported that the body of data, as large as it is, does not demonstrate that exposure to power-frequency magnetic fields causes cancer or poses other health risks, although the possibility cannot be dismissed. Because of the uncertainty, most reviews recommend further research, and, appropriately, research is ongoing worldwide. The weakness of the reported associations, the lack of consistency among studies, and the severe limitations in exposure assessment in the

epidemiological studies, along with the lack of support from laboratory studies, were key considerations in the findings of the scientific reviews.

The International Agency for Research on Cancer (IARC), a part of the World Health Organization (WHO), conducted the most recent major EMF review.<sup>4</sup> The organization's Fact Sheet No. 263 on that review states:

In June 2001, an expert scientific working group of IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Using the standard IARC classification that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans based on epidemiological studies of childhood leukaemia. Evidence for all other cancers in children and adults, as well as other types of exposures (i.e., static fields and ELF electric fields) was considered not classifiable either due to insufficient or inconsistent scientific information.

'Possibly carcinogenic to humans' is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals.

This classification is the weakest of three categories ('is carcinogenic to humans,' 'probably carcinogenic to humans,' and 'possibly carcinogenic to humans') used by IARC to classify potential carcinogens based on published scientific evidence.

The Health Council of the Netherlands released a 27-page advisory report on "the possible health effects of extremely-low-frequency (ELF) electromagnetic fields" to the Dutch government on May 29, 2001. A council press release issued the same day stated:

Present scientific data do not indicate that exposure to environmental electromagnetic fields—such as generated by powerlines and mobile phone base stations—constitute a health hazard. This is the thrust of the first Annual Update on Electromagnetic Fields presented today by the Health Council of the Netherlands, a major scientific advisory body of the Dutch Government, to the Ministers of the Environment and Health.

In March 2001, an independent advisory group to the National Radiological Protection Board (NRPB) in the United Kingdom published a wide-ranging and thorough review of scientific research on EMF. The review covers work published since the NRPB's first major review of the topic in 1992 and supplementary reports in 1993 and 1994. The report concludes that the possibility of an effect cannot be dismissed:

Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in

children.... In the absence of clear evidence of a carcinogenic effect in adults, or of a plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless, however, further research indicates that the finding is due to chance or some currently unrecognized artefact, the possibility remains that intense and prolonged exposures to magnetic fields can increase the risk of leukaemia in children.

#### **8.4 FEDERAL ELECTRIC AND MAGNETIC FIELDS PROGRAM**

In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act (PL 102-486, Section 2118). The Congress instructed the National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health and the Department of Energy to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to ELF-EMF. This program was completed in December 1998. In June 1999, NIEHS published its report (*Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*) with its findings and conclusions from this program of research.

The 1999 NIEHS report concluded:

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak ... The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukaemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern.

Panels charged with recommending exposure limits for electric and/or magnetic fields have concluded that no meaningful experimental data exist (e.g., no dose-response information is available) on which to base standards or limits to which the public is exposed.

#### **8.5 STATE ELECTRIC AND MAGNETIC FIELDS POLICY**

In January 1991, the CPUC issued an Order Instituting Investigation I. 91-01-012 to develop policies and procedures for addressing potential health effects of magnetic fields from utility facilities. The CPUC formed the California Consensus Group (CCG), a committee of 17 stakeholders representing diverse interests and perspectives, to provide guidance on interim EMF measures the CPUC might adopt while waiting for resolution of scientific uncertainties.

In March 1992, the CCG issued its report. In part, the report recommended that the CPUC authorize utilities to implement magnetic field reduction techniques if those techniques could be implemented at little or no cost. In November 1993, the CPUC issued Decision D. 93-11-013 adopting an interim policy regarding EMF. The CPUC found that the scientific community had not concluded that an EMF health hazard actually exists.

Further, the CPUC stated, “It is not appropriate to adopt any specific numerical standard in association with EMFs (sic) until we have a firm scientific basis for adopting any particular value.” However, “public concern and scientific uncertainty remain regarding the potential health effects of EMF exposure.” In response, California’s electric utilities were authorized to implement no- and low-cost<sup>5</sup> field management techniques to reduce EMF levels from new and upgraded electrical facilities if a noticeable reduction could be achieved.<sup>6</sup>

The CPUC’s Commission Advisory and Compliance Division (CACD) set and chaired informational EMF Design Guideline workshops to incorporate concepts and criteria addressed in the Order and to share information on field reduction options. SDG&E’s EMF Design Guidelines for Transmission, Distribution, and Substation Facilities (*EMF Design Guidelines*) describe engineering techniques for reducing exposure to magnetic fields created by its electrical facilities.

The CPUC acknowledged in its order that the feasibility and cost of implementing specific magnetic field reduction techniques vary among utility systems and from project to project. Therefore, the CPUC provided that the manner in which individual utilities apply design guidelines must be determined within the constraints of each new construction project. A project-specific *EMF Management Plan* is attached.

The following sections detail applicable management techniques and guidelines that would be used in the design of this project.

### **8.5.1 Miguel–Mission 230kV Transmission Circuit**

The use of existing structures and right-of-way for the new 230kV transmission circuit allows for good field management practices by the use of optimal phasing, or phasing that results in the greatest field reduction. Optimization of field reduction will come through the use of configuration techniques and phase orientation with respect to the other transmission lines sharing the existing right-of-way.

### **8.5.2 Relocated 69kV and 138kV Circuits**

Optimal phasing would be a consideration in the relocation of the 69kV and 138kV circuits onto new structures between Miguel Substation and Fanita Junction. Power flow will dictate whether same orientation of phasing (ABC/ABC) or low-reactance (reverse orientation) phasing (ABC/CBA) will be used with the new double-circuit steel pole structure line.

### **8.5.3 Miguel and Mission Substations**

During the detailed design stage, it is recommended that high current devices be kept away from the fence and brought into the substation as much as possible; that equipment be located as close to the center of the substation as possible; that buses and cables be oriented so that parallel runs are as far from the station fences as possible. It is also recommended that the phase currents on the transmission circuits entering and leaving the substation be balanced.

## **8.6 CALIFORNIA ENVIRONMENTAL QUALITY ACT**

Given the uncertainty of EMF effects and the inability of scientific investigations to identify any unsafe level or component of EMF exposure, potential EMF impacts are appropriately addressed as speculative in accordance with the CEQA Guidelines, Section 15145.<sup>7</sup>

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<sup>1</sup> Wertheimer, N. and E. Leeper. 1979. *Electrical Wiring Configurations and Childhood Cancer*. American Journal of Epidemiology 109:273-284.

<sup>2</sup> Savitz, D.A. et al. 1988. *Case-control study of childhood cancer and exposure to 60-Hz magnetic fields*. American Journal of Epidemiology (128): 21–38; Severson, R.K. et al. 1988. *Acute nonlymphocytic leukemia and residential exposure to power-frequency magnetic fields*. American Journal of Epidemiology (128): 10–20; London, S.J. et al. 1991. *Exposure to residential electric and magnetic fields and risk of childhood leukemia*. American Journal of Epidemiology (134): 923–937.

<sup>3</sup> California Public Utilities Commission/California Department of Health Services, *Potential Health Effects of Electric and Magnetic Fields From Electric Power Facilities*, 1989; International Radiation Protection Association/International Non-ionizing Radiation Committee, *Interim Guidelines on Limits of Exposure to 50/60-Hz Electric and Magnetic Fields*, 1990; American Conference of Governmental and Industrial Hygienists, *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*, 1991; U.S. Environmental Protection Agency, *Evaluation of the Potential Carcinogenicity of Electromagnetic Fields, Review Draft*, 1990; U.S. Environmental Protection Agency Science Advisory Board, Peer Review of Draft Report: *Evaluation of the Potential Carcinogenicity of Electromagnetic Fields*, 1992; Oak Ridge Associated Universities, Committee on Interagency Radiation Research and Policy Coordination, *Health Effects of Low-Frequency Electric and Magnetic Fields*, 1991–1993; State of Texas Public Utility Commission, Electro-magnetic Health Effects Committee, *Health Effects of Exposure to Powerline-Frequency Electric and Magnetic Field*, 1992; State of Illinois Department of Public Health, *Possible Health Effects of Extremely Low Frequency Electric and Magnetic Fields Exposure: A Review*, 1992; Universities Consortium on Electromagnetic Fields, *Investigation in Powerline Frequency EMF and Its Risks to Health: A Review of the Scientific Literature*, 1992 and 1994; Connecticut Academy of Science and Engineering, *Electromagnetic Field Health Effects*, 1992; Institut National de la Santé et de la Recherche Médicale, *Synthesis of the Literature on Health Effects From Very Low Frequency Electric and Magnetic Fields*, 1993; Danish Ministry of Health, *Report on the Risk of Cancer in Children Living in Homes Exposed to 50 Hz Magnetic Fields From High Voltage Lines*, 1993; National Radiological Protection Board, United Kingdom, *Electromagnetic Fields and the Risk of Cancer, Supplementary Report by the Advisory Group on Non-ionising Radiation*, 1994; American Medical Association, *Effects of Electric and Magnetic Fields, Report 7 of the Council on Scientific Affairs*, 1995; American Physical Society, *Background Paper on Powerline Fields and Public Health*, 1995; American Cancer Society, *Electromagnetic Field Exposure and Cancer: A Review of Epidemiologic Evidence*, 1996; Virginia Department of Health, *Monitoring of Ongoing Research on the Health Effects of High Voltage Transmission Lines*, 1996; National Academy of Sciences, *Possible Health Effects from Exposure to Electric and Magnetic Fields*, 1997; National Institute of Environmental Health Sciences, Director's Report to Congress, *Health Effects From Exposure to Power-Line Frequency Electric and Magnetic Fields*, 1999; State of Virginia Department of Health, *Monitoring of Ongoing Research on the Health Effects of High Voltage Transmission Lines*, 2000; National Radiological Protection Board, United Kingdom, Advisory Group on Non-ionising Radiation, *Power Frequency Electromagnetic Fields and the Risk of Cancer*, 2001; Health Council of the Netherlands, *Electromagnetic Fields, Annual Update 2001*, 2001; International Agency for Research on Cancer, *Static and Extremely Low Frequency Electric and Magnetic Fields*, Vol. 80, 2002.

<sup>4</sup> International Agency for Research on Cancer. 2002. *Static and Extremely Low Frequency Electric and Magnetic Fields*, Vol. 80.

<sup>5</sup> Decision 93-11-013 defines “low cost” as in the range of 4 percent of total cost as a budgeted project.

<sup>6</sup> SDG&E defines “noticeable reduction” as 15 percent.

<sup>7</sup> If after thorough investigation a particular impact is found to be too speculative for evaluation, the conclusion shall be noted, and the discussion terminated (CEQA, 1986).



