APPENDIX A
Electric and Magnetic Fields

Appendix A.1

Electric and Magnetic Fields Summary

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The California Public Utilities Commission (CPUC) and the California Department of Health Services (CDHS) have not concluded that exposure to magnetic fields from utility electric facilities is a health hazard. Many reports have concluded that the potential for health effects associated with electric and magnetic field (EMF) exposure is too speculative to allow the evaluation of impacts or the preparation of mitigation measures. EMF is a term used to describe electric and magnetic fields that are created by electric voltage (electric field) and electric current (magnetic field). Power frequency EMF is a natural consequence of electrical circuits, and can be either directly measured using the appropriate measuring instruments or calculated using appropriate information. EMF are present wherever electricity flows: around appliances and power lines, in offices, schools, and homes. Electric fields are invisible lines of force, created by voltage, and are shielded by most materials. Units of measure are volts per meter (V/m). Magnetic fields are invisible lines of force, created by electric current and are not shielded by most materials, such as lead, soil and concrete. Units of measure are Gauss (G) or milliGauss (mG, 111000 of a Gauss). Electric and magnetic field strengths diminish with distance. These fields are low energy, extremely low frequency fields, and should not be confused with high energy or ionizing radiation such as X-rays and gamma rays.

Possible Health Effects

The possible effects of EMF on human health have come under scientific scrutiny. Concern about EMF originally focused on electric fields; however, much of the recent research has focused on magnetic fields. Uncertainty exists as to what characteristics of magnetic field exposure need to be considered to assess human exposure effects. Among the characteristics considered are field intensity, transients, harmonics, and changes in intensity over time. These characteristics may vary from power lines to appliances to home wiring, and this may create different types of exposures. The exposure most often considered is intensity or magnitude of the field. There is a consensus among the medical and scientific communities that there is insufficient evidence to conclude that EMF causes adverse health effects. Neither the medical nor scientific communities have been able to provide any foundation upon which regulatory bodies could establish a standard or level of exposure that is known to be either safe or harmful. Laboratory experiments have shown that magnetic fields can cause biologic changes in living cells, but scientists are not sure whether any risk to human health can be associated with them. Some studies have suggested an association between surrogate measures of magnetic fields and certain cancers while others have not.

California Public Utilities Commission Summary

Background

On January 15, 1991, the CPUC initiated an investigation to consider its role in mitigating the health effects, if any, of electric and magnetic fields from utility facilities and power lines. A working group of interested parties, called the California EMF Consensus Group, was created by the CPUC to advise it on this issue. It consisted of 17 stakeholders representing citizens groups, consumer groups, environmental groups, state agencies, unions, and utilities. The Consensus Group was charged to 1) consider a balanced set of facts and concerns; 2) define near- term research objectives; and 3) develop interim policies and procedures to guide the electric utilities in educating their customers, reducing EMF, and responding to potential health concerns. The Consensus Group's fact-finding process was open to the public, and its report incorporated concerns expressed by the public. Its recommendations were filed with the CPUC in March of 1992. In August of 2004, the CPUC opened an Order Instituting Rulemaking to update the CPUC's policies and procedures related to electric and magnetic fields emanating from regulated utility facilities. The final decision was issued in D.06-01-042.

Findings

Based on the work of the Consensus Group, written testimony, and evidentiary hearings, the CPUC issued its decision (D.06-01-042) to address public concern about possible EMF health effects from electric utility facilities. The conclusions and findings included the following:

- The body of scientific evidence continues to evolve. However, it is recognized that public concern and scientific uncertainty remain regarding the potential health effects of EMF exposure.
- It is not appropriate to adopt any specific numerical standard in association with EMF until we have a firm scientific basis for adopting any particular value.

Interim Policies

The CPUC's decision specifically requires seven measures. One of these measures that is applicable to the Missouri Flat-Gold Hill 115 kV Power Line Reconductoring Project is as follows:

- *No-cost and low-cost steps to reduce EMF*. In response to a situation of scientific uncertainty and public concern, the CPUC felt it appropriate for utilities to take no-cost and low-cost measures where feasible to reduce exposure from new or upgraded utility facilities. It directs that no-cost mitigation measures be undertaken, and that low-cost options be implemented through the project certification process. Four percent of total project budgeted cost is the benchmark in developing EMF mitigation guidelines, and mitigation measures should achieve some noticeable reductions.

The CPUC will continue to monitor these issues. If new information develops in the future, the CPUC may amend its decision to reflect new scientific evidence.

Exemption Criteria

The CPUC agreed that "Utility management should have reasonable latitude to deviate and modify their guidelines as conditions warrant and as new EMF information is received. However, if the EMF guidelines are to be truly used as guidelines, the utilities should incorporate criteria which justify exempting specific types of projects from the guidelines."

Utilities may use the following guidelines to determine those specific types of projects that will be exempt from no/low cost field reduction:

1. Operation, repair, maintenance replacement or minor alteration of existing structures: facilities or equipment.
2. Restoration or rehabilitation of deteriorated or damaged structures, facilities or equipment to meet current standards of public safety.
3. Addition of safety devices.
4. Replacement or reconstruction of existing structures and facilities on the same site and for the same purpose as the replaced structure or facility.
5. Emergency restoration projects.
6. Re-conductoring projects except when structures are reframed or reconfigured.
7. Projects located on land under the jurisdiction of the Forest Service, Bureau of Land Management or other governmental agency.
8. Privately owned tree farms.
9. Agricultural land within the Williamson Act.
10. Areas not suited to residential/commercial development. Such areas might include steep slopes, areas subject to flooding or areas without access to public facilities.

The intent of the exemption criteria is to exclude two types of projects. The first type of project is one that either replaces or makes minor additions or modifications to existing facilities. This will include pole replacements or relocations less than 2,000 feet in length. Those projects where more than 2,000 feet of line is relocated or reconstructed or where the circuit is reinsulated or reconfigured should be considered for low cost magnetic field management techniques. The second type of project is one located in undeveloped areas.

EMF Reduction

Utilities must use the following Guidelines in the application of no and low cost steps to reduce magnetic field strengths:

1. Take low cost steps to reduce fields from new and upgraded facilities in accordance with CPUC decision D.06-01-042 on EMF.
2. No cost measures will be implemented when available and practical.
3. Mitigation measures should not compromise the reliability, operation, safety, or maintenance of the system.

4. Total cost of mitigation measures should not exceed four percent of the total cost of the Project.
5. Mitigation measures should have a noticeable reduction in the magnetic field level approximately 15 percent or more.

In accordance with CPUC Decision Nos. 93-11-013 and 06-01-042, PG&E will incorporate "no cost" and "low cost" magnetic field reduction steps for the proposed power line reconductorings. For additional information, see Appendices A.2 and A.3, which further describe PG&E's field management plans for the Project. The following measures would be included to reduce the magnetic field strength levels from electric power facilities:

Missouri Flat-Gold Hill 115 kV line Nos. 1 and 2

PG&E proposes to raise the height of thirteen poles in the school and residential land use areas by 10 feet taller than required for meeting General Order 95. The phases of the Missouri Flat-Gold Hill 115 kV line No. 2 would be arranged for minimum magnetic field level at the edge of the right of way. The phasing would be changed from Shingle Spring Substation to Clarksville Substation to Gold Hill Substation:

- Missouri Flat-Gold Hill 115 kV line No. 1 Phasing Top-C, Middle-B, Bottom-A; and
- Missouri Flat-Gold Hill 115 kV line No. 2 Phasing Top A, Middle-B, Bottom-C.

Gold Hill 60 kV line No. 1

The operating voltage of the 60 kV line would be increased to 115 kV. This voltage increase would reduce magnetic field levels by 47 percent. PG&E proposes to raise the height of 29 poles in the high density residential land use areas 10 feet taller than required for meeting General Order 95.

Appendix A.2

Field Management Plan for
Missouri Flat-Gold Hill
115 kV Line Nos. 1 and 2

TRANSMISSION MAGNETIC BASIC FIELD MANAGEMENT PLAN
MISSOURI FLAT-GOLD HILL 115 KV LINES RECONDUCTORING PROJECT

I. General Description of Project

Project Lead: Project Manager, Electric Transmission Maintenance and Construction

Transmission Lines: Missouri Flat-Gold Hill 115 kV line #1
Missouri Flat-Gold Hill 115 kV line #2

Distribution line Underbuild: 21 kV.

Scope of Work:

The current scope of work is to reconductor Missouri Flat-Gold Hill 115 kV lines No. 1 and 2 (~ 25 miles long total for both circuits) with 795 kcmil ACSS (Condor) conductor. These 2 lines are on a Double Circuit Pole Line (DCPL) and Double Circuit Tower Line (DCTL); the scope starts from 2 spans northeast of Shingle Spring Substation (pole 22/174) to Shingle Spring Substation, then to Clarksville Substation and ends at Gold Hill Substation. The Gold Hill-Clarksville 115 kV line and the Gold Hill 60 kV No. 1 lines (also a DCTL) run parallel to the Missouri Flat-Gold Hill 115 kV No. 1 & 2 lines from Clarksville Substation to Gold Hill Substation.

II. BACKGROUND: CPUC DECISION 93-11-013 AND EMF POLICY

On January 15, 1991, the CPUC initiated an investigation to consider its role in mitigating the health effects, if any, of electric and magnetic fields from utility facilities and power lines. A working group of interested parties, called the California EMF Consensus Group, was created by the CPUC to advise it on this issue. It consisted of 17 stakeholders representing citizens groups, consumer groups, environmental groups, state agencies, unions, and utilities. The Consensus Group's fact-finding process was open to the public, and its report incorporated concerns expressed by the public. Its recommendations were filed with the Commission in March 1992.

In August 2004 the CPUC began a proceeding known as a "rulemaking" (R.04-08-020) to explore whether changes should be made to existing CPUC policies and rules concerning EMF from electric transmission lines and other utility facilities.

Through a series of hearings and conferences, the Commission evaluated the results of its existing EMF mitigation policies and addressed possible improvements in implementation of these policies. The CPUC also explored whether new policies are warranted in light of recent scientific findings on the possible health effects of EMF exposure.

The CPUC completed the EMF rulemaking in January 2006 and presented these conclusions in Decision D.06-01-042:

- The CPUC affirmed its existing policy of requiring no-cost and low-cost mitigation measures to reduce EMF levels from new utility transmission lines and substation projects.

- The CPUC adopted rules and policies to improve utility design guidelines for reducing EMF, and provides for a utility workshop to implement these policies and standardize design guidelines.

- Despite numerous studies, including one ordered by the Commission and conducted by the California Department of Health Services, the CPUC stated "we are unable to determine whether there is a significant scientifically verifiable relationship between EMF exposure and negative health consequences."

- The CPUC said it will "remain vigilant" regarding new scientific studies on EMF, and if these studies indicate negative EMF health impacts, the Commission will reconsider its EMF policies and open a new rulemaking if necessary.

In response to a situation of scientific uncertainty and public concern, the decision specifically requires PG&E to consider "no-cost" and "low-cost" measures, where feasible, to reduce exposure from new or upgraded utility facilities. It directs that no-cost mitigation measures be undertaken, and that low-cost options, when they meet certain guidelines for field reduction and cost, be adopted through the project certification process. PG&E was directed to develop, submit

and follow EMF guidelines to implement the CPUC decision. Four percent of total project budgeted cost is the benchmark in implementing EMF mitigation, and mitigation measures should achieve incremental magnetic field reductions of at least 15%.

III. ELECTRIC AND MAGNETIC FIELDS (EMF)

EMF is a term used to describe electric and magnetic fields that are created by electric voltage (electric field) and electric current (magnetic field). Power frequency EMF is a natural consequence of electrical circuits, and can be either directly measured using the appropriate measuring instruments or calculated using appropriate information.

Electric fields are present whenever voltage exists on a wire, and are not dependent on current. The magnitude of the electric field is primarily a function of the configuration and operating voltage of the line and decreases with the distance from the source (line). The electric field can be shielded (i.e., the strength can be reduced) by any conducting surface, such as trees, fences, walls, buildings, and most types of structures. The strength of an electric field is measured in volts per meter (V/m) or kilovolts per meter (kV/m).

Magnetic fields are present whenever current flows in a conductor, and are not dependent on the voltage of the conductor. The strength of these fields also decreases with distance from the source. However, unlike electric fields, most common materials have little shielding effect on magnetic fields.

The magnetic field strength is a function of both the current on the conductor and the design of the system. Magnetic fields are measured in units called Gauss. However, for the low levels normally encountered near electric utility facilities, the field strength is expressed in a much smaller unit, the milliGauss (mG), which is one thousandth of a Gauss.

Power frequency EMF are present wherever electricity is used. This includes not only utility transmission lines, distribution lines, and substations, but also the building wiring in homes, offices, and schools, and in the appliances and machinery used in these locations. Magnetic field intensities from these sources can range from below 1 mG to above 1,000 mG (1 Gauss).

Magnetic field strengths diminish with distance. Fields from compact sources (i.e., those containing coils such as small appliances and transformers) drop off with distance “r” from the source by a factor of $1/r^3$. For three-phase power lines with balanced currents, the magnetic field strength drops off at a rate of $1/r^2$. Fields from unbalanced currents, which flow in paths such as neutral or ground conductors, fall off inversely proportional to the distance from the source, 1/r. Conductor spacing and configuration also affect the rate at which the magnetic field strength decreases, as well as the presence of other sources of electricity. The magnetic field levels of PG&E’s power lines will vary with customer demand.

Magnetic field strengths for typical transmission power line loads at the edge of rights-of-way are approximately 10 to 90 mG.

IV. No-Cost and Low-Cost Magnetic Field Mitigation

Base Case Phasing:

From Shingle Spring Sub to Clarksville Sub to Gold Hill Sub –

Missouri Flat-Gold Hill 115 kV line #1 Phasing	Top-C, Mid-B, Bot-A
Missouri Flat-Gold Hill 115 kV line #2 Phasing	Top B, Mid-A, Bot-C

Optimally Phase Circuits:

The phases of the Missouri Flat-Gold Hill 115 kV line #2 will be arranged for minimum magnetic field level at the edge of the right of way. The phasing will be changed to the following:

From Shingle Spring Sub to Clarksville Sub to Gold Hill Sub –

Missouri Flat-Gold Hill 115 kV line #1 Phasing	Top-C, Mid-B, Bot-A
Missouri Flat-Gold Hill 115 kV line #2 Phasing	**Top A, Mid-B, Bot-C**

V. General Description of Surrounding Land Uses

Schools or Daycare: Two poles.
Residential (rural): Eleven poles & thirteen towers.
Commercial/Industrial: Twenty-four poles.
Recreational: None.
Agricultural, Rural, and Undeveloped Land: Twenty-two poles & four towers.

Priority Areas where Low Cost Measures are to be Applied

The thirteen poles and thirteen towers in the school and residential land use areas are considered for magnetic field reduction.

The FMP does not propose to raise the thirteen lattice steel towers on the Missouri Flat-Gold Hill 115 kV line (structure nos. 31/231 to 33/247) for EMF mitigation due to structural reasons. PG&E is installing a larger conductor at a higher tension than these towers were originally designed for, and the existing towers without any raises are capable of supporting the new

conductor with mostly minor modifications (the tower supporting the cell antennas is the exception).

Following is a summary of the three options evaluated for raising these towers:

- Cage top extensions – due to the conductor loading of the new wire, a typical cage top extension cannot be installed on the towers without significant modifications to the towers; this raise type of extension is not recommended by engineering for this project.

- Waist cage extensions – while these extensions are technically feasible, they would still require significant structural modifications. Another drawback with the waist cage extensions is the need for access for large cranes for lifting - access to the towers in the residential areas is not very good and would cause significant ground disturbance and impose on the residents. This type of extension is not recommended by engineering for this project.

- Vertical extensions – these extensions are placed at the base of the tower, which requires the existing tower to have level/even leg extensions; none of the towers in the residential area has level/even legs so this option to raise the towers is not feasible.

This FMP proposes to raise the height of thirteen poles in the school and residential land use areas by 10 feet taller than required for meeting General Order 95. No other low-cost mitigation is available for this project.

VI. Conclusion - Field Reduction Options Selected

This FMP proposes to raise the height of thirteen poles in the school and residential land use areas by 10 feet taller than required for meeting General Order 95. No other low-cost mitigation is available for this project.

The phases of the Missouri Flat-Gold Hill 115 kV line #2 will be arranged for minimum magnetic field level at the edge of the right of way. The phasing will be changed to the following:

From Shingle Spring Sub to Clarksville Sub to Gold Hill Sub –

Missouri Flat-Gold Hill 115 kV line #1 Phasing	Top-C, Mid-B, Bot-A
Missouri Flat-Gold Hill 115 kV line #2 Phasing	**Top A, Mid-B, Bot-C**

Appendix A.3

Field Management Plan for Gold Hill 60 kV line No. 1

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

I. General Description of Project

Project Lead: Project Manager, Electric Transmission Maintenance and Construction

Transmission Line: Gold Hill #1 60 kV line.

Distribution line Underbuild: 21 kV.

Scope of Work:

This job is a Shoofly Upgrade to 115kv from Gold Hill Sub to a few poles past Shingle Springs Sub. Transmission Conductor will be upgraded to 715A from Clarksville Sub to a few poles past Shingle Springs (approximately 7 miles) which will require reframing and/or replacing of existing poles. Most poles are accessible when dry with a few exceptions. Most all poles have distribution under-build.

Base Cost of Project: Approximately $8,500,000

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

II. BACKGROUND: CPUC DECISION 93-11-013 AND EMF POLICY

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The CPUC completed the EMF rulemaking in January 2006 and presented these conclusions in Decision D.06-01-042:

- The CPUC affirmed its existing policy of requiring no-cost and low-cost mitigation measures to reduce EMF levels from new utility transmission lines and substation projects.

- The CPUC adopted rules and policies to improve utility design guidelines for reducing EMF, and provides for a utility workshop to implement these policies and standardize design guidelines.

- Despite numerous studies, including one ordered by the Commission and conducted by the California Department of Health Services, the CPUC stated "we are unable to determine whether there is a significant scientifically verifiable relationship between EMF exposure and negative health consequences."

- The CPUC said it will "remain vigilant" regarding new scientific studies on EMF, and if these studies indicate negative EMF health impacts, the Commission will reconsider its EMF policies and open a new rulemaking if necessary.

In response to a situation of scientific uncertainty and public concern, the decision specifically requires PG&E to consider "no-cost" and "low-cost" measures, where feasible, to reduce exposure from new or upgraded utility facilities. It directs that no-cost mitigation measures be undertaken, and that low-cost options, when they meet certain guidelines for field reduction and cost, be adopted through the project certification process. PG&E was directed to develop, submit and follow EMF guidelines to implement the CPUC decision. Four percent of total project

budgeted cost is the benchmark in implementing EMF mitigation, and mitigation measures should achieve incremental magnetic field reductions of at least 15%.

III. ELECTRIC AND MAGNETIC FIELDS (EMF)

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Power frequency EMF are present wherever electricity is used. This includes not only utility transmission lines, distribution lines, and substations, but also the building wiring in homes, offices, and schools, and in the appliances and machinery used in these locations. Magnetic field intensities from these sources can range from below 1 mG to above 1,000 mG (1 Gauss).

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Magnetic field strengths for typical transmission power line loads at the edge of rights-of-way are approximately 10 to 90 mG.

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

IV. General Description of Surrounding Land Uses

Schools or Daycare: None.

Residential: One hundred-four poles.

High Density Residential	29
Low Density Residential	62
Multi-Family Residential	13

Commercial/Industrial: Thirty-three poles.

Recreational: None.

Agricultural, Rural, and Undeveloped Land: Fifty-three poles.

V. No Cost and Low Cost Magnetic Field Mitigation

No Cost Field Reduction

The operating voltage of the 60 kV line will be increased to 115 kV. This voltage increase will reduce magnetic field levels by 47%.

Priority Areas where Low Cost Measures are to be Applied

One hundred-four poles are in the residential land use area for consideration of magnetic field reduction.

Low Cost Magnetic Field Reduction Options

This FMP proposes to raise the height of twenty-nine poles in the high density residential land use areas ten feet taller than required for meeting General Order 95. No other low cost mitigation is available for this project.

VI. Conclusion - Field Reduction Options Selected

The operating voltage of the 60 kV line will be increased to 115 kV. This voltage increase will reduce magnetic field levels by 47%.

This FMP proposes to raise the height of twenty-nine poles in the high density residential land use areas ten feet taller than required for meeting General Order 95. No other low cost mitigation is available for this project.