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Electric and Magnetic Fields (EMF) RAPID Engineering Program

Project 7: DEVELOPMENT OF FIELD EXPOSURE MODELS

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ABSTRACT

The purpose of this project was to develop a conceptual model for estimating magnetic field (EMF) personal exposure (PE) of individuals or groups and construct a working model using existing data. This model estimates an individual's total exposure over selected time periods or within a general environment (home, work, school, travel, and other). Baseline fields that have been adjusted for residential and other factors and fields from sources are combined with time, location, and source usage information to estimate exposure for three magnetic field parameters: time-weighted-average field, peak field, and presence of harmonic fields. In addition to field levels for locations and sources, required inputs to the model include information about a subject's residence, activities, and occupation. This information is collected via a subject diary and/or interviewer-administered survey of a subject. Specific environments and factors affecting fields in those environments were identified from previously reported research, and expert opinion. These same resources provided magnetic field point estimates and probability distributions for use as inputs to the model. Estimates of fields during Work were based on a job-exposure matrix. The assignment of field levels in the working model was compromised by a paucity of data for many inputs. This compelled the assumption of sometimes arbitrary hypothetical field levels and distributions for certain inputs in order to demonstrate the model.

The working model was implemented on a spreadsheet combined with commercial modeling software. The software allowed the introduction of point estimates, common distributions, and known empirical distributions for model inputs. The outputs were point estimates and estimated distributions for the modeled exposures.

The working model was tested in a small pilot study involving 20 subjects in the Oakland, CA area. This effort tested the interview process and provided data for use in comparing measured and modeled exposure. Subjects wore a personal exposure meter (EMDEX II) for 24 hours. The meter recorded broadband and harmonic magnetic field levels at 5 second intervals. Half the subjects maintained a simple diary which recorded their general location during the measurement period. The other half were interviewed later and retrospectively constructed a diary of their activities during the measurement period. All subjects were interviewed to elicit the more detailed information needed by the model (e.g., whether an electric hair dryer was used and if so, when and for how long). These diary and interview data were used by the model to estimate exposures for each subject. The distributions of estimated exposure were compared with measured exposure to assess the functionality of the model.

The pilot study provided a limited and relatively homogeneous sample of subjects, which was adequate for implementation of the model but was inadequate for a thorough validation of the model. The pilot demonstrated the adequacy of both a retrospective and concurrent diary, when combined with an interview, to collect time, location, and source usage information from the subjects. The uncertainties in time information were insignificant compared to those associated with the field level point estimates and distributions of the model inputs.

Data from the pilot study indicated that:

- the model responded to changes in field levels, time and status as expected;
- the estimated exposures were generally greater than the measured exposures for all three field parameters;
- there are large uncertainties in modeling the contribution of sources to TWA and peak exposures;

- estimated TWA exposure in the model is most strongly influenced by field levels inside the home and at work (for this limited sample no subjects had significant time at school); and
- the field distributions associated with the environment categories in the model (e.g., underground and overhead lines) are too broad to provide useful estimates of individual exposures.

The principal impediment to magnetic field exposure models of this type appears to be the lack of readily identifiable categories that define narrow field level distributions for detailed environments and the plethora of sources. Efforts to improve models must address both the large variability in exposure components and the lack of field level data. To assess the exposure of a single individual at this time, it appears that simple survey or PE measurements will produce a better estimate of exposure than will a model based on additional information about subject, environment or source attributes obtained from a questionnaire and/or interview.

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1

INTRODUCTION

1.1 Purpose

The purpose of this project is to develop a model for estimating magnetic field (EMF) personal exposure (PE) of individuals or groups within the general population. This model estimates an individual's total exposure over selected time periods or within a general environment (home, work, school, travel, and other). Exposures are estimated for three magnetic field parameters: time-weighted-average field, peak field, and harmonic fields. Baseline fields that have been adjusted for residential and other factors and fields from sources are combined with time, location and source usage information to estimate exposure for the three magnetic field parameters. In addition to field levels for locations and sources, required inputs to the model are data related to a subject's residence, activities, and occupation. This information is collected via a diary or interviewer-administered survey of a subject. The project involved a pilot study with 20 subjects. This measurement effort tested the interview process and provided data for use in model simulations.

1.2 Background

Exposure assessments that entail measurements are costly and time-consuming. Furthermore, they may not provide results which are indicative of a subject's exposure spanning different locations and activities occurring on different days in different seasons. It is often impractical to perform such an EMF exposure assessment for large populations. Therefore EMF exposure models based on information collected via interview or direct observation or that related to group characteristics offer an attractive alternative.

EMF computational modeling efforts have been undertaken to estimate the fields in certain environments and the fields produced by certain sources. For example, simple computer models based on first principles have been developed to compute fields from transmission lines assuming infinite parallel conductors [Deno and Zaffanella, 1982]. Other more sophisticated computations that allow finite non-planar conductors can be used to model fields in complicated environments such as substations [Enertech Consultants, 19??]. Mader and Peralta [1992] employed the physical properties of dipole sources and measured fields to perform spatial averaging of fields near appliances. However, these field-computation models are not adequate to predict personal exposure to EMF because they do not incorporate information about the time people spend in these environments, the activities they perform in the environments, and the EMF sources they use.

To model personal EMF exposure requires the integration of time and activity information with field data. For example, time-activity data have been integrated with field measurements to estimate TWA exposures to electric fields [Silva, M. et al., 1985], TWA and peak exposures to appliances [Kaune et al., 1996], and exposure distributions for employees and visitors in other settings (hospitals, grocery stores, machine shops, offices and schools) [Zaffanella, 1996]. This project investigated methodologies for constructing a time-location model based on field levels from the literature and time-location data from interviews or diaries.

1.3 Project Overview

Development of the field model in this project entailed several steps: selecting the field parameters to be modeled; identifying environments, locations, and sources with distinct field levels; assigning field levels to environments, locations, and sources; establishing combinatorial rules for fields associated with different factors affecting fields in an environment; determining subject, residence, time, and location data for subjects; specifying the computation of exposures for the selected parameters; and implementing the model.

Time-weighted-average (TWA), peak, and harmonic magnetic-field exposures are the selected output parameters. Specific environments and factors affecting fields in those environments were identified from previous research, measurements, and expert opinion. These same sources provided point estimates and probability distributions for inputs to the models. For example, assignment of the baseline exposure inside an urban home with overhead electric service is based on measurements of residential PE in a large number of homes with these characteristics as reported by the Long-term Wire Code Study [Bracken et al., 1998]. This baseline could be adjusted for a house which is old (over 30 years old) based on results from both the LTWC study and the 1000-Homes Study [Zaffanella, 1993]. The additional effects of the use of certain appliances could be based on the collective results of several measurement projects. The method of combining different inputs to produce an estimated exposure depends on the nature of the input's contribution to exposure and can be replacement, algebraic addition, or addition in quadrature.

The information used to determine the proper model attributes and the allocation of time periods to environments and activities are determined by diaries and interviews. Both a diary maintained by a subject during measurements and a retrospective diary produced via an interview after the measurements were developed and used in a pilot study. Interviews are used to provide additional details needed by the model. The model could also accept expert opinion in place of the diary and interview information. This would allow an estimation of the exposure of groups of subjects based solely on hypothetical time inputs.

Algebraic computations combined the field levels appropriate to the subject and their location with the time data to produce exposure estimates for all three field parameters. The model was implemented as a spreadsheet (Excel®) on a personal computer operating under Windows 95®. Risk-analysis software (@Risk®) facilitated the introduction of probability distributions for input variables and produced probability distributions for the exposure estimates.

The modeling process was tested in a small pilot study involving 20 subjects in the Oakland, CA area. Subjects wore a personal exposure meter (EMDEX II) for 24 hours. The meter recorded broadband and harmonic magnetic field levels at 5 second intervals. Half the subjects maintained a simple diary which recorded their general location during the measurements. The other half were interviewed after the measurement period and retrospectively constructed a diary of their activities during the measurement period. All subjects were interviewed to elicit the more detailed information needed by the model (e.g., whether a hair dryer was used and if so, when and for how long). These diary and interview data were used as inputs to the model which then estimated exposures for each subject. The distributions of these estimated exposures were compared with the measured exposures to assess the functionality of the model.

It should be emphasized that the model was intended as a demonstration of concepts and techniques only. The assignment of field levels is limited by a paucity of data for many inputs. This compelled the assumption of sometimes arbitrary hypothetical field levels and distributions for certain inputs. The small number of pilot study subjects and the limited diversity of their measured exposures limits the ability to validate the results of this model.

Details of the steps involved in developing the model are provided in the remainder of this report. Section 2 provides details on the structure of the model including computational details. The assignment of fields to environments, locations and sources is described in Section 3. Interviews, diaries and other data collection forms are described in Section 4. Implementation of the model is the subject of Section 5. The pilot study methods and results are described in Sections 6 and 7, respectively. Our observations and conclusions are discussed in Section 8. References are cited Section 9. Appendices contain supporting materials and additional details on the execution and results of the project.

2

MODEL DESCRIPTION

The purpose of the model is to generate magnetic field exposure estimates for individuals and groups based on known field levels and time-activity information. Exposures are modeled for five basic environments (Home, School, Work, Travel, and Other). Baseline field levels for each environment and field levels for each source constitute the magnetic field data required by the model. Data for time-weighted-average (TWA) field, peak field, and harmonic field are provided to estimate exposures for each of these field parameters. Time-activity data is provided by questionnaires or other sources and is combined with the field data in the computation of estimated exposures.

The general structure of the model is described in this section. The selection of specific components and assignment of values to these components are discussed in Section 3. The model is constructed in a spreadsheet format to allow easy incorporation of new information. This format also allows the introduction of both point estimates and probability distributions for the input variables to the model.

2.1 Exposure Environments

The model divides the time period of interest into exposure environments corresponding to time spent at Home, time spent at School, time spent at Work, time spent in Travel, and time spent in Other areas. Selection of these particular environments reflects the relatively large amounts of time that can be spent there, the generally different activities that are performed in each environment, and the ability of subjects to discern time spent in these environments. Also different sources can be associated with the environments and the different activities that take place in them.

Exposures in each environment are derived from two field components: an environment-related baseline component and a component related to using and being near sources. The field components are combined with time-activity information in the exposure model to produce exposure estimates for individuals or groups. The actual combination of field values and time-activity information will depend on the environment, the availability of time-activity information, and the magnetic field parameter under consideration.

Field values assigned to each environment and source are determined from a review of the literature or original research. Values for time in environment and using sources are determined from a questionnaire or other source of time-activity data. Exposures are computed for time in each environment and for the total time period.

2.2 Baseline Fields

The baseline fields represent field levels that are present during all activities in an environment. There may be more than one baseline level in an environment corresponding to different general locations or conditions. The baseline fields are assigned to any activities that are not associated with specific EMF sources and that, consequently, do not increase EMF exposure above background levels.

In general, the baseline component consists of a minimal field level for the environment plus any adjustments due to factors that affect field levels throughout the environment. Adjustments that contribute to the baseline include field increments for urban versus rural locales and inside versus outside locations. Baseline levels can be assigned to both inside and outside locations in an environment. There can also be adjustments for area EMF sources: for example, baseline exposure in the Home environment can be increased if the home is located near a transmission line. The applicable baseline field for a subject is based on information from a questionnaire or other data source for the particular occupied environment.

The environments and the factors that go into adjustments for the baseline level are given in Table 2.1. The rationale for selecting these factors and the assignment of values to them is described in Section 3.

The Work environment is treated as a special case. If possible, the subject is associated with a job title in a job exposure matrix (JEM). The baseline level is then obtained from the JEM. In this case, the baseline level includes exposures associated with the locations, activities, and sources found in that job. If no job title is available, then the baseline level can be determined from the nature of the environments encountered during work.

2.3 EMF Sources

High EMF sources associated with activities in an environment are identified and included as part of the exposure model. Initially, specific activities were considered as possible exposure components. However, activities may involve much time and different sources, making it difficult to assign specific field levels to them. In addition, associated with each activity were sources that could be assigned specific field levels. Consequently, the emphasis in the exposure model is on sources rather than activities.

Generally, the time using or near a source is of much shorter duration than the time in the environment. Therefore, sources commonly influence peak exposures, rather than mean exposures. However, in some cases, sources may also directly impact the computation of TWA and harmonic exposures in the model. Therefore the amount of time a source is used is needed for the computation of exposures.

The possibility that use of particular sources is already incorporated into the computation of average field say, for a job title, could lead to double-counting of the contribution of sources in TWA exposure. By using average baseline fields based on large samples and by only including sources with fields significantly above baseline levels, the impact of including sources fields twice in exposure computations should be minimized.

Sources generally refer to appliances, tools, or other devices that are operated personally by a subject or by someone in close proximity to the subject. Close proximity refers to distances comparable to those at which the subject would be during operation of the device or tool. Only electrically powered devices that are energized from a wall socket are included as sources. In special cases, a known producer of high fields not operated by an individual can be identified and included as a source.

For the purposes of demonstrating this model, a limited number of sources were selected for inclusion. Typical sources for each environment are shown in Table 2.2. Assignment of field values to specific sources is discussed in Section 3. In the Home environment, sources are grouped in the following categories: outside, kitchen, household, personal care, office, entertainment/hobbies, tools, and Not-otherwise-classified (NOC). In the School environment, sources are grouped in the following categories: classroom, office, shop/tools, and NOC. In the Work environment, sources are grouped in the following categories: office, hand tools, stationary power equipment, large power tools, and NOC. In the Other environment, sources are grouped in the general activity categories of recreational/entertainment, shopping, personal business, travel, and NOC.

2.4 Home Environment

The Home environment is defined as the area in and around the place of residence and activities that take place there. It includes activities outside the residence when the residence is the base for such activities. For example, gardening is a Home activity, but walking through the garden to leave the residence is not.

2.4.1 Home: Baseline

The Home exposure environment represents an area with fairly common and specific characteristics. Magnetic field levels and exposures in this environment have been extensively characterized with measurements. Therefore sufficient measurement data are available to permit assignment of baseline field levels to the Home environment. Specific factors that enhance (or, in rare cases, decrease) the minimal field level at a house can be identified and quantified. These factors are: locale - urban or rural; location - outside, inside, or in the kitchen; house characteristics - such as size, age, and single/multi-family dwelling status; house wiring; external electrical configurations such as the presence of transmission lines; and heating type.

2.4.2 Home: Sources

Activities in the Home environment can be divided into those taking place outside and those taking place inside. Specific sources included in this model for outside activities are electric hand tools such as a hedge clipper or trimmer. EMF sources are in use during such inside activities as preparing food, personal care, and hobbies. To facilitate identification, the sources used in inside activities are divided into the general categories of kitchen, household, personal care, hobbies/entertainment, and tools.

The very high fields associated with some specialized sources suggest that their use may have to be determined specifically. These include home welding equipment, and electric blankets. Work at home in a home office is included in the Work environment.

2.5 School Environment

The School environment is defined as the area and activities performed in and on the campus of an institution established for the purposes of instruction in a skill and/or other learning activity plus school-related travel. For pre-schoolers and children, this includes day-care centers and schools. For adults and seniors, activities in this environment include: visiting day-care centers and schools in the role of parent or guardian; attending high school or college; and attending other schools such as institutions for the teaching of music, business skills or trades. Not included are on-the-job apprentice or training programs; these are included in the Work environment.

Baseline and source components in the School environment apply to exposures of students at school. For teachers, administrators and school staff, school is their place of work and this exposure is included in the Work environment. Volunteers at school are considered to be in the Other environment, and their activities fall within the general activity Personal Business (See Other environment).

2.5.1 School: Baseline

The baseline component for the School environment will be adjusted for urban and rural locales and inside and outside locations. Other factors that adjust the baseline level for a school are type of campus and external electrical wiring.

2.5.2 School: Sources

Activities in the School environment will be divided into those taking place outside, those taking place inside, and travel during school. EMF-related sources that may occur inside are: power tools in a shop/vocational class, electrical appliances in a home economics class, electric tools or equipment in laboratories/classes, and audio-visual equipment. Specific high-field appliances found in schools include: slide/overhead projectors, electric pencil sharpeners and small office appliances, power tools, welding equipment, and soldering equipment.

2.6 Work Environment

The Work environment consists of locations where activities related to work are performed. It may be an actual place of work or, as in the case of someone whose work entails travel, a number of places.

2.6.1 Work: Baseline

The Work environment encompasses diverse locations and activities that can not be easily described with a set of specific characteristics. Therefore the model relies on a job title to assign a baseline level for an individual or group. The job title is linked to exposure through a job exposure matrix (JEM) for magnetic fields. The general JEM for EMF exposures used in the model was developed at the University of Washington and is based on the Standard Occupational Classification (SOC) codes [Yost et al., 1997]. The job titles in this JEM are general (two-digit as opposed to four-digit level) and are listed in Table 2-3. Exposures in the JEM are based on personal exposure (PE) measurements reported in the literature and provide estimates of actual exposures for a group. TWA exposures are provided for all job titles, but peak exposures are available for only a limited number of job titles and harmonic exposures are not available for any job titles in the JEM. Peak and harmonic exposures in the Work environment are, therefore, based on reported PE and survey measurements in the Work environment for large numbers of persons or places.

In the event that a job title does not match one found in the JEM, then baseline field levels are assigned to estimated time spent in urban and rural locales, outside and inside, and in specific work locations. In these cases, emphasis is placed on identifying sources that may contribute exposures above baseline levels.

2.6.2 Work: Sources

As with the other environments, high-field sources are identified in the Work environment for determination of their possible contribution to exposures in specific cases. Specific sources of interest in the Work environment are listed in Table 2-2.

2.7 Other Environment

The Other environment is defined as locations and activities that fall outside the other three environments.

2.7.1 Other: Baseline

The Other environment, like the Work environment, encompasses many diverse areas and locations. Therefore, a simple default value is used for the baseline component with adjustments only for locale (urban/rural) and location (inside/outside). Locations in the Other environment that are assigned specific baseline values are grocery stores and remote areas away from power-lines.

2.7.2 Other: Sources

To identify possible sources of exposure in the Other environment, several general types of activities are identified. These are: recreation/entertainment, shopping, personal business, travel, and not-otherwise-classified (NOC). Within each general activity, specific EMF-related sources are identified. For example, the general activity personal business includes activities that involve health care, beauty care, volunteer and religious activities, and meetings with professionals. Specific high-field sources that might be used or encountered during such activities include medical imaging facilities, hair dryers, office equipment, etc.

2.8 Field Parameters

Three different exposure parameters are represented in the model: time-weighted-average (TWA) exposure, peak exposure, and harmonic exposure. These were selected to be illustrative and are not intended to be exhaustive of the parameters that could be modeled using this technique.

TWA exposure to magnetic fields was selected because of its frequent use in biologic and epidemiologic studies and because of the extensive TWA data available for various groups and for many environments. TWA exposure refers to a whole-body average and normally would be measured at the torso or head.

Peak field exposure was selected to demonstrate how extreme exposures could be modeled. Peak field exposure refers to the maximum field experienced at the surface of the body including extremities. Data on peak fields are commonly reported and can be estimated from a knowledge of sources present in an area or associated with an activity. Care must be exercised in assigning peak values from PE measurements, because they are usually made at the surface of the torso and do not capture peak field at the extremities. Conversely, verification of peak values predicted by the model is problematic because of the difficulty of capturing maximum values at the extremities.

The third parameter to be modeled is more qualitative: harmonic fields are characterized in the model only by the fraction of time they are likely to be present and above a specified threshold. Because data on harmonic fields are limited, the data presented for this parameter and the resulting model are the most speculative.

The model for each parameter entails different evaluation and inclusion criteria and separate computational formulae for each parameter.

2.9 Time-activity Information

Time-activity information for subjects and groups can be determined from interviews, questionnaires, expert panels, diaries, or other methods. The model requires time spent in the five basic environments and time spent using or near EMF-related sources. Estimates of the time spent in environments and near sources is used to weight the estimates for the TWA and harmonic field parameters.

For the Work environment, if a job title linked to a JEM is available, determination of time in sub-environments or activities is not required. In this case, the job title and information about specific high-field sources used or present in the specific workplace provide sufficient information to assign an exposure to the Work environment.

2.10 Exposure Computations

2.10.1 TWA

The estimation of TWA exposure requires values for: time spent in each environment, baseline field levels for each environment, time spent near each source, and field level for each source. Only sources that contribute exposures above the baseline level are included in computing TWA exposure.

The estimate of TWA_I in the I*th* environment is obtained as follows:

$$TWA_I = \{BLA_I x T_I \sum_i [(BAVE_i - BLA_I) \times T_i]\} / T_I.$$

where: TWA_I = time-weighted average in environment I,

I = environment (Home, School, Work, Other),

i = sources in environments,

BLA_I = average baseline component for environment I,

T_I = total time reported for environment I,

$BAVE_i$ = average field level for EMF source i in the environment, and

T_i = time reported for source i in the environment.

Both the field level for an activity and the time in an activity will depend on the reference group and is determined from questionnaires.

The time-weighted-average exposure for the entire time, TWA, is given by:

$$TWA = \sum_I (TWA_I \times T_I) \ / \ \sum_I T_I .$$

The cumulative exposure (μT·hrs or mG·hrs) can be modeled by omitting the denominator from the above computations.

2.10.2 Peak

Peak exposures are estimated by environment and for the entire period of interest. The computation of peak exposure entails a search of the maximum values for the baseline and source exposure components. The highest maximum value from all sources (including baseline) in an environment is selected as the peak exposure for the individual or group in that environment. Because sources tend to have the highest maximum field levels, they are of particular importance to the assessment of peak exposure.

The peak exposure, PK_I, in environment I is given by:

$$PK_I = \text{MAXIMUM}\ \{BLP_I, BPK_1, BPK_2, \ldots, BPK_i, \ldots, BPK_n\},$$

where BLP_I = maximum field in the baseline component,
BPK_i = maximum field due to the *ith* EMF source in environment I,
n = number of EMF sources in the environment, and
the MAXIMUM function produces the maximum value found in its arguments.

The peak exposure, PK, for the entire time period is given by:

$$PK = \text{MAXIMUM}\ \{PK_1, PK_2, PK_3, PK_4, PK_5\},$$

where the subscripts 1 to 5 refer to the five environments (Home, School, Work, Travel, and Other).

2.10.3 Harmonics

An estimated level of harmonics is indicated for each baseline component and source. The estimate can be either a value expressed as a relative percentage of resultant field level or an absolute value in mG.

The measure for exposure to harmonics is computed by determining the fraction of time that harmonics may be present for a subject in an environment or in all environments.

The fraction is computed as the fraction of time harmonic levels in the baseline component and from sources exceed a specified harmonic field level.

The potential harmonic exposure above a threshold B_T in an environment is expressed as a fraction of the time in the environment, $FH_I(B_T)$, and given by:

$$FH_I(B_T) = [T_I(BLH_I>B_T)+\sum_i T_i(BH_i>B_T)]/T_I$$

where $FH_I(B_T)$ = fraction of time harmonics are estimated to be above B_T in the baseline component of environment I,

I = environment (Home, School, Work, Travel, and Other)

BLH_i = estimated harmonic level in environment I,

BH_i = estimated harmonic level for EMF source i,

T_I = total time reported for environment I,

T_i = time reported for EMF source i in the environment,

$T_I(BLH_I>B_T)$ = time in environment I with harmonic field above threshold (excluding $\sum T_i(BH_i>B_T)$), and

$T_i(BH_i>B_T)$ = time for source with harmonic field above threshold.

The harmonic exposure for the entire period, FH, is given by:

$$FH = \sum_I(FH_I \times T_I)/\sum_I T_I .$$

Table 2-1
Baseline Fields by Environment

Environment	Typical Adjustments to Baseline
Home	Locale: urban/rural Location: outside/inside /inside kitchen House characteristics: size, age, single/multi-family status, wiring External wiring: transmission line, overhead lines Heating: electric floor or ceiling heat in use
School	Locale: urban/rural/remote Location: outside/inside External wiring: transmission line, overhead lines Type of school: traditional, residential, commercial
Work	
Travel	Locale: urban/rural External wiring: overhead lines
Other	Locale: urban/rural/remote Location: inside/outside/grocery store

Table 2-2
Typical EMF Sources by Environment

Environment	General Source Category	Source
Home	Outside	Electric tools: hedge trimmer, weed eater, chain saw
	Kitchen	Hand-held appliances: can opener, blender, electric knife, etc. Large appliances: Electric stove, microwave oven, etc.
	Household	Electric heater, fluorescent lamp, iron, vacuum
	Personal care	Electric hair dryer, corded electric razor, heating pad, electric blanket
	Office	Copier, pencil sharpener
	Entertainment/hobbies	Aquarium, sewing machine
	Tools	Electric hand tools: drills, saws, soldering iron. Large tools: table saw
	Not-otherwise-classified (NOC)	Home welder, portable generator
School	Classroom	Overhead/slide projector
	Office	Computer Copier, pencil sharpener
	Shop/tools	Electric hand tools: drills, saws, soldering iron Welding set
	NOC	
Work	Office	Copier Un-interruptible power supply (UPS)
	Hand tools	Drills, saws, sanders
	Stationary power tools	Lathes, saws, drill presses, sanders
	Large power equipment	Demagnetizers, motor generator sets, electric furnaces, welders
	NOC	
Other	Recreation/entertainment	
	Shopping	
	Personal business	
	Travel	
	NOC	

Table 2-3
Job Titles in EMF General Job Exposure Matrix.
Job codes based on Standard Occupational Classification (SOC) codes

Job Code	Job Title
1100	officials and administrators, public administration
1213†	officials and administrators, other
1400	management-related occupations
1600	engineers, surveyors and architects
1700	computer, mathematical, and operations research occupations
1800	natural scientists
1900	social scientists and urban planners
2000	social, recreation, and religious workers
2100	lawyers and judges
2200	teachers; college, university and other post-secondary institution
2300	teachers, except post-secondary institution
2600	physicians and dentists
2800	other health diagnosing and treating practitioners
2900	registered nurses
3200	writers, artists, performers, and related workers
3300	editors, reporters, public relations specialists, and announcers
3600	health technologists and technicians
3700	engineering and related technologists and technicians
3800	science technologists and technicians
3900	technicians, except health, engineering, and science
4000	supervisors; marketing and sales occupations
4100	insurance, securities, real estate, and business service sales
4200	sales occupations, commodities, except retail
4300	sales occupations, retail
4500	supervisors; administrative support occupations, including clerical
4647†	administrative support occupations, including clerical
5100	protective service occupations
5200	service occupations, except private household and protective
5500	farm operators and managers
5600	other agricultural and related occupations
5700	forestry and logging occupations*
6100	mechanics and repairers
6400	construction trades
6500	extractive occupations
6800	precision production occupations
6900	plant and system operators
7100	supervisors; production occupations
7374†	machine setup operators
7576†	machine operators and tenders
7700	fabricators, assemblers, and hand working occupations
7800	production inspectors, testers, samplers, and weighers
8100	supervisors; transportation and material moving occupations
8200	transportation occupations
8300	material moving occupations, except transportation
8700	handlers, equipment cleaners and laborers
9100	military occupations

* This data is based solely on the Floderus, 1995 study

† Job codes 1213, 4647, 7374, and 7576 were created by combining two major group numbers in the Standard Occupational Classification codes; e. g., group 1213 denotes all codes beginning with a 12 or 13.

3

MAGNETIC FIELD VALUES

3.1 Literature Database

Approximately 350 articles, reports and abstracts related to EMF measurements and exposure assessment were reviewed and classified to provide a basis for selecting factors that contribute to EMF exposure and for assigning magnetic-field values to environments and sources. Complete citations and summary information about the content of these references were entered into a Microsoft Access® database for searching and retrieval. In the summary portion of the database, each record contains information on the reference groups, environments, and exposure factors described in a reference. Other characteristics of the study that are recorded include: sample size, geographic location, measured field parameter(s), type of measurement, instrumentation, and other data items. A listing of the reference characteristics and their values that are recorded in the database is given in Table 3.1. A list of the 231 citations in the database and sample output listings are printed in Appendix A. Information about all characteristics was not necessarily available for, or did not necessarily apply to, each study.

The database was searched to yield all references with, say, EMF measurements in the School environment. The resulting references were then reviewed to identify and quantify, if possible: 1) baseline-field levels in schools; 2) factors that might be applied as adjustments to obtain baseline levels in schools; and 3) field levels associated with EMF sources in schools. An analogous procedure was used for all environments to develop an understanding of and values for the magnetic fields found there. The completion of two large measurement projects in the RAPID program provided valuable data for baseline, adjustments and source levels [Zaffanella, 1996; Zaffanella and Kalton, 1998].

3.2 Inclusion Criteria for Baseline and Adjustment Factors

The model relies on being able to identify EMF exposure scenarios, that is, recognizing those locations, situations, or sources which result in exposures above baseline levels. Selection of factors that contribute to exposure above baseline depends on the summary measure being modeled; that is, factors that affect TWA exposure may not impact peak exposure.

To simplify the evaluation of factors for inclusion in the model, each potential adjustment factor is assigned a point estimate based on measured values in the literature. The point estimate, typically the mean, is compared with point estimate from baseline fields. If the adjustment factor exceeds the baseline level by 0.2 mG or more, it is included in the model. Ultimately, in our implementation of the model, point values are replaced by probability distributions to produce a stochastic model. In other words, factors will be evaluated for inclusion in the context of a deterministic model, but the model accommodates probability distributions to provide more realistic results.

3.2.1 TWA

The outside TWA baseline levels are taken as the average background field for houses in areas with underground or overhead electrical service or a nearby transmission line, as determined by point-in-time measurements. The inside TWA baseline levels are the average PE fields, measured in houses in areas with different types of electrical service. Only factors that increase or, in rare cases, decrease the magnetic field over a large area of the environment in question will be included as adjustments to the baseline value. Thus, each environment includes several baseline levels, corresponding to urban (includes suburban) and rural locales, inside and outside locations, and different types of nearby electric distribution and transmission facilities.

To be considered as an adjustment to the baseline value, the change in field associated with the factor must, in general, meet the following criteria: 1) occur over a large area; 2) be essentially continuous over time, i.e., contributing to the background field; 3) be reported exclusively and consistently in the literature or, if limited data are available, the reporting must be consistent with present understanding of magnetic fields and sources; 4) be quantified in studies with adequate sample sizes in several geographical regions; 5) preferably be based on PE or extensive area measurements; and 6) be readily identified by a respondent during an interview. However, for the sake of example, adjustments that do not completely meet these criteria have been included in the model; e.g., electric heat and electric blankets.

Selection of a specific numerical threshold for the inclusion of a factor in baseline values is not straightforward because of the large variability of baseline values. For the purposes of this model, inclusion as an adjustment to the TWA baseline value required that, on average, an increase (or decrease) of at least 0.2 mG in the field be attributable to the factor. Numerous factors met this criterion, and the following have been included in the model: house size (floor area); house age; single-family and multi-family dwellings; the presence of only 2-prong electrical outlets; whether the house is connected to a well; and the presence and operation of electric ceiling heat systems. There are undoubtedly other factors that could have been considered.

3.2.2 Peak Values

The peak value in an environment is taken as the maximum of PE measurements in that environment. PE measurements capture both baseline and source fields and represent maximum fields from sources that may or may not have been included in responses to the questionnaire.

Adjustment to baseline peak-field values for a factor requires only that the peak for the factor exceed that for the baseline level. Because peak exposures are generally determined by sources, the assignment of baseline peak values is not as critical as the assignment of baseline TWA and harmonic levels.

3.2.3 Harmonics

For the harmonic field summary measure, the model utilizes an arbitrary threshold level in milligauss (mG) as the criterion for inclusion in the computation of fraction of time with harmonics present. The harmonic field is the square root of the sum of the squares of all frequency components above 60 Hz. The harmonic level in mG during a specific time is then compared to the selected threshold to compute the fraction of the total time with harmonics present above the threshold.

3.3 Source Inclusion Criteria

In order for sources to be included in the exposure model, they must meet criteria similar to those applied to the baseline adjustment factors. EMF sources must: 1) be reported extensively and consistently in the literature or, if limited data are available, the reporting must be consistent with present understanding of magnetic fields and sources; 2) be quantified in several studies or in a study with measurements for several sources of the same type; 3) be based on measurements performed with a well-defined protocol; 4) represent a field value that exceeds the baseline levels; and 5) be easily identified by respondents during an interview. Because of their large number and range of measured fields, possible sources were assigned to the general field-level categories of low, medium and high at TWA- and peak-exposure distances. Field levels for these categories are shown in Table 3.2.

The fields that are found at a typical distance from a source during its use can affect TWA exposure. The TWA-exposure distance corresponds to the distance from the source to the torso or head during normal use. For most stationary and hand-held appliances and tools, this distance is about 0.3 m, corresponding to use at arm's reach with bent elbows. The TWA-exposure distance is also used for harmonic-field exposures.

For peak-field exposure, the location of interest is either at the surface of the source or at the closest practical proximity for a user. Thus, the peak-exposure distance is generally less than the TWA- and harmonic-exposure distance. In assigning field values at the peak-exposure distance, the distance from the actual source inside the appliance or tool to its surface is estimated, if possible.

Peak fields for hand-held appliances or tools are taken at the surface, corresponding to exposures to the hands. The distances for peak exposures assigned to the selected sources were generally 0.0 or 0.1 m.

For the purposes of this model, only sources with TWA fields in the medium and high categories are considered important. Fields in the low category are commonly present in all environments and their inclusion would likely introduce sources that are already accounted for in the baseline levels. Furthermore, sources in the low category are numerous and comprehensive inclusion of them would be tedious and impractical. The use of specific field thresholds for the upper two categories allows for easy screening of appliances and grouping of appliances for inclusion in the TWA-exposure model. Only sources with peak values in the medium or high category, are included in the peak exposure model. Sources included in the harmonic-field exposure model were limited to those in the medium or high category for TWA-exposure.

3.4 Home Environment

3.4.1 TWA, Home

Baseline TWA magnetic field levels for the Home environment are initially determined by the locale—urban or rural, and by the location—outside or inside. The baseline level is also affected by the nature of nearby electrical facilities. Depending on other factors associated with the residence, the baseline level may be changed. The new adjusted level then becomes the basis for exposure estimates.

For illustration purposes, baseline fields and adjustments were combined in two ways in the model. For some factors, the magnitude of adjustments were added directly to (or subtracted from) baseline levels. For other factors, the baseline and adjustment fields were treated as random vectors with the average total field magnitude computed as the square root of the sum of the squares of the baseline and adjustment fields (added in quadrature). The choice of combinatorial method for a particular factor depended on its association with other factors in the model and the perceived impact of the factor on TWA-exposure levels. For example, the field adjustments for being in the kitchen and for house connected to a well were added directly to baseline level due to the independence. While, due to their association, the field adjustments for house age and presence of two-prong plugs were added in quadrature with the baseline level. Factors added directly to baseline obviously have more effect on the adjusted baseline than those added in quadrature.

TWA fields in the Home environment are based on two extensive surveys of residential fields: the EPRI Long Term Wire Code (LTWC) Study [Bracken et al., 1998] and the EPRI 1000-Homes Study [Zaffanella, 1993]. Both studies have limitations in terms of the data they can provide for the model. The LTWC Study was conducted with a random sample of single-family residences at eight sites in the U.S. No multi-family dwellings were included. PE measurements were collected by residents for up to four visits to a home. The 1000-Homes Study employed a random sample of homes of all types but did not include PE measurements. Thus, the studies did not involve the same population of houses or comparable measurements. However, for the outside and inside point-in-time (spot) measurements that were comparable, similar distributions of mean field levels were observed in the two studies some confidence in their suitability for incorporation into the model. Choosing appropriate point estimates and distributions for the various baseline levels involved selecting field levels that were consistent across these studies and were consistent with our basic understanding of residential magnetic field exposures. We relied on both studies for outside baseline data, where fields were low and not influenced by sources. For estimates of inside levels, we relied on PE data from the LTWC Study. Empirical distributions were constructed from the data in tables in the reports for the two projects. This should be contrasted with the distributions selected for adjustments to baseline levels which were hypothetical because data on the actual distributions were not available.

Exposure levels outside a residence where sources do not contribute to PE can be characterized by spot measurements or by PE measurements. Estimates of the field levels inside a residence, on the other hand, are best characterized by PE measurements that capture variability due to movement in the presence of the local sources that are found in a home. On the other hand, adjustments to inside baseline levels were based on survey measurements from the 1000-Homes Study.

In the models, the factors that determine baseline levels for a particular residence, as well as the time spent in the residence, are obtained via interview/questionnaire. For example, responses will indicate: whether the baseline level for a rural or urban locale is appropriate, and the appropriate period of time for inside or outside locations. Responses may indicate the need to adjust these baseline levels to reflect specific EMF factors: for example, the presence of transmission lines near a residence or the presence of two-prong electrical outlets in a residence. Point estimates, distributions, and combinatorial methods for the TWA baseline and adjustment field levels in the Home environment are summarized in Table 3.3 and discussed below. The empirical cumulative distributions for the Home environment are given in Table 3.4.

3.4.1.1 Baseline Levels

Rural-outside The rural-outside baseline level is founded on estimates of power-line fields at rural houses in the 1000-Homes Study. The point estimate, for the rural-outside baseline is 0.3 mG (the mean of the average power-line field for rural homes). If a transmission line is present, this baseline is replaced with the outside with transmission line baseline (point estimate 2.2 mG) No direct comparison of the rural power-line field from the 1000-Homes study is possible with measurements reported in the LTWC study.

Rural-inside. The rural-inside baseline level is based on the PE mean for houses in the very-low current configuration (VLCC) category in the LTWC Study[1]. The selection of this category to represent rural houses is supported by the observation that over 55 percent of rural houses were in the VLCC category in the 1000-Homes Study. The point estimate for the rural-inside level is 0.6 mG (mean of average PE field for VLCC houses). The empirical distribution for the average PE field in a house (PE Mean) in the VLCC category is used for the distribution of field levels. For comparison, the mean of average spot measurements at the center of all rooms for VLCC houses in the 1000-Homes Study was 0.6 mG and the mean of spot measurements for rural houses in the 1000-Homes Study was 0.5 mG.

Urban-outside: underground. The urban outside baseline level is founded on estimates of power-line fields in the 1000-Homes Study. The power-line fields are considered those responsible for outside exposures. When the house is in an area with an

[1]The wire-code category of a house is based on its proximity to electrical distribution and transmission facilities and the characteristics of those facilities. [Cf. Kaune et al., 1987; Bracken et al., 1988].

underground distribution system (UG), then the power-line fields measured near UG houses represent the baseline for urban (and suburban) dwellings. The baseline estimate derived from the UG power-line fields is reasonably consistent with perimeter fields measured for UG houses in the LTWC study. The point estimate for the urban-outside UG baseline is 0.43 mG. The distribution is empirical, based on tabular data from the 1000-Homes Study as shown in Table 3-4.

Urban-inside: underground. The urban-inside UG baseline is founded on the average of PE means for UG houses in the LTWC Study. The point estimate for the urban-inside UG field level is 0.6 mG. The distribution of field levels is based on the empirical distribution of PE means from the UG houses in the LTWC Study. For comparison, the mean of average spot measurements at the center of all rooms for UG houses in the 1000-Homes Study was 0.7 mG.

Urban-outside: overhead lines. The outside field level for urban houses with overhead lines (OH) nearby is founded on measured power-line fields in the 1000-Homes Study. The OLCC category is the most prevalent of urban overhead line categories. The point estimate for the baseline level is 0.83 mG and the distribution used is the empirical distribution from the LTWC Study as shown in Table 3-4.

Urban-inside: overhead lines. The inside level for urban houses with overhead lines nearby is estimated from the average PE for houses in the OLCC category from the LTWC Study. The point estimate for inside exposure in this baseline case is 1.2 mG and the empirical distribution for average PE from the LTWC Study is used. The rural-inside category is not adjusted for nearby overhead lines since the baseline in that category is founded on the field levels from the VLCC category.

Outside: transmission line. The presence of transmission lines within 45 m (150 feet) of a house can contribute to field levels outside the house. The field levels outside a house with a transmission line nearby are based on measurements of the power-line field near such houses in the 1000-Homes Study. This baseline value replaces the field level for urban-outside (UR or OH) or rural-outside baseline as appropriate. The distribution of fields selected for houses near transmission lines is the empirical distribution of mean power-line field for houses with a transmission line (Type 23 line) nearby in the 1000-Homes Study. The point estimate for the outside transmission-line baseline field level is 2.2 mG.

Inside: transmission line. The presence of transmission lines within 45 m (150 feet) of a house can increase the field levels inside a house. The increased levels used in the model are based on average spot measurements for houses with transmission lines (Type 23) nearby from the 1000-Homes Study. The point estimate for the inside: transmission line level is 2.3 mG. The distribution is based on the empirical distribution of spot measurement means from the 1000-Homes Study. The new level replaces baseline levels for the urban-inside (UG or OH) or rural-inside field levels in houses with transmission lines nearby. Inside spot measurements for homes near transmission lines in the EMDEX Residential Study were higher with a mean of 3.4 mG [Bracken et al., 1994]. However, the houses in this latter study were not randomly selected.

3.4.1.2 Adjustments to Baseline Field

Kitchen. Kitchens have been observed to have somewhat higher fields than the remainder of the house [Zaffanella, 1993]. This may be associated with the presence of more electrical appliances and lights in that room than in other rooms. In particular, refrigerators can represent a significant field source in kitchens and are treated as an adjustment rather than an activity-related source. The baseline level for time spent in the kitchen is adjusted to reflect the higher fields found there. However, specific sources related to food preparation and other kitchen activities are treated separately in the model.

The field level adjustment for to the kitchen is based on spot measurements performed during the 1000-Homes Study where the average field in the kitchen was observed to be approximately 0.2 mG above the average point-in-time measurements in all other rooms of the house. For the purposes of modeling, the incremental field in the kitchen is assumed to be a truncated log-normal distribution with the following parameters: mean 0.2 mG; standard deviation 0.1 mG. The distribution is truncated at 1 mG to eliminate unrealistically large increments. The increment is added directly to the inside baseline field assigned to the rest of the house.

House size: >1800 sq. ft. The 1000-Homes Study observed a decrease in the spot measurements associated with increased house floor area [Zaffanella, 1993]. A similar relationship between house size and field level was observed in the LTWC Study [Bracken et al., 1998]. The decrease in field with larger house size could be associated with greater distances from internal wiring or with increased distance from external wiring because of larger lot size. The average field for houses with living space greater than approximately 1800 sq. ft. was about 0.3 mG less than that for smaller houses. A similar difference was noted in the median 24-hour fields for larger and smaller houses [Zaffanella, 1993]. Since only about one third of houses are larger than 1800 sq. ft., the adjustment is treated as a reduction and is subtracted directly from the baseline for large houses. The point estimate for the adjustment is 0.3 mG. The assumed distribution for the decrement is truncated log-normal with a mean of 0.3 mG, and standard deviation of 0.1 mG. The distribution is truncated at 0.8 mG to eliminate unrealistically large increments. The model does not allow the adjusted inside baseline to go below 0.05 mG.

Connected to well. Residential electrical grounding is often through the water system. In houses attached to private wells, the presence of fields from ground currents is substantially reduced relative to houses with ground paths through a conductive water system [Zaffanella, 1993; Lanera et al., 1997]. The use of a well also generally indicates a rural locale. The observed reduction in average spot measurements in houses with wells compared to those connected to a water system was 0.4 mG in the 1000-Homes Study [Zaffanella, 1993]. Much of this could be attributed to the primarily rural location of houses with wells. Therefore, the point estimate for this reduction is assumed to be only 0.2 mG in the model. The distribution is taken to be truncated log-normal with the following parameters: mean, 0.2 mG and standard deviation, 0.1 mG. The distribution is truncated at 0.4 mG to eliminate unrealistically large increments. The reduction is applied to rural houses only and is subtracted directly from the inside baseline, with the constraint that the inside baseline cannot be less than 0.05 mG.

House age: >30 years. The 1000-Homes Study observed an increase in the average field with house age. This same effect was seen in the LTWC Study and to some extent in the EMDEX Residential Study. This increase in field level could be related to older wiring types and conductive plumbing found in older houses, both of which can affect fields [Lanera et al., 1997]. The increase of field levels with house age could also be related to the trend of higher wire codes for older houses [Zaffanella, 1993; Bracken et al., 1994]. In the 1000-Homes Study, houses more than 30 years old had average point-in-time measurements about 0.3 mG greater than those less than 30 years old. This observation is introduced into the model as an adjustment to the inside baseline level. The assumed distribution for the adjustment is a truncated log-normal distribution with a mean of 0.2 mG and a standard deviation of 0.1 mG. The distribution is truncated at 0.8 mG to eliminate unrealistically large increments. This adjustment is added in quadrature to the inside baseline.

Multi-family dwelling. Multi-family dwellings tend to have higher fields than single-family dwellings [Zaffanella, 1993]. Therefore, an adjustment to inside field levels is made in the model. Based on observations from the 1000-Homes Study, a point estimate increase of 0.3 mG is used for multi-family residences. The assumed distribution for this factor is truncated log-normal with the following parameters: mean 0.3 mG, and standard deviation 0.2 mG. The distribution is truncated at 1.3 mG to eliminate unrealistically large increments. This adjustment is added in quadrature to the inside baseline.

Two-prong outlets. The presence of any two-prong electrical outlets in a house is associated with elevated field levels relative to houses with only three-prong (grounded) outlets present. The presence of two-prong outlets is associated with the age of the house and the presence of fields from ground current [Zaffanella, 1993]. The presence of two-prong outlets may be the only easily observed factor associated with grounding efficacy in a house. The average of point-in-time measurements in houses with only two-prong outlets was about 0.5 mG greater than that in houses with only three-prong plugs present and 0.3 mG greater than for houses with both types of plugs present [Zaffanella, 1993]. For modeling purposes, the point estimate for the incremental field associated with the presence of two-prong plugs is taken as 0.2 mG. The distribution is taken as a truncated log-normal distribution with the following parameters: mean 0.2 mG and standard deviation 0.1 mG. The distribution is truncated at 0.7 mG to eliminate unrealistically large increments. The field increment associated with two-prong outlets is added in quadrature to the inside baseline field.

Electric ceiling heat. Electric ceiling (or floor) heat represents a potential area source inside a residence. The field level at a height of 1 meter from the floor in rooms with electric ceiling heat in operation is approximately 3.0 mG [Zaffanella, 1993]. The average field increment attributed to electric ceiling heat is dependent on the duty cycle when the heat is on. The 1000-Homes Study estimated a 10% duty cycle during the heating season. Thus, the point estimate for the average contribution of electric ceiling heat is 0.3 mG. The distribution of this incremental field is assumed to be a truncated normal distribution with the following parameters: mean, 0.3 mG; standard deviation, 0.2 mG. The distribution is truncated at 1.3 mG to eliminate unrealistically large increments. The increment is added in quadrature to the inside baseline.

3.4.2 Peak, Home

Although most peak exposures will be associated with sources, peak field levels are still assigned to baseline conditions. Peak levels are assigned to urban and rural settings without regard to location outside or inside. For purposes of the model, the maximum for PE measurements was selected to represent peak baseline fields. These values represent peak fields associated with area and local sources. Unlike for TWA exposure values, no adjustments to the baseline peak values are made for inside kitchen, transmission lines nearby, overhead lines nearby or for the housing characteristics of size, age, multi-family dwelling, presence of two-prong plugs, connection to a well or use of electric ceiling heat. Point estimates, distributions and combinatorial methods for peak baseline levels are given in Table 3.5 and discussed below.

Rural-outside and rural-inside. The peak level assigned to rural-outside and rural-inside locations is the maximum of long-term fixed-location measurements in the VLCC category from the EMDEX Residential Study [Bracken et al., 1994]. (Peak values were not published for the LTWC study.) The point estimate (mean) for rural peak baseline field is 10 mG. The empirical cumulative distribution for VLCC houses from the EMDEX Residential Study is assumed for the rural peak baseline field. The peak field must be greater than or equal to the TWA baseline value for any iteration of the model.

Urban: outside and urban: inside. The peak level assigned to urban locations is the maximum of long-term fixed-location measurements in houses in the OLCC category from the EMDEX Residential Study [Bracken et al., 1994]. The point estimate for the peak is 15 mG. The empirical cumulative distribution for OLCC houses from the same study is assumed for peak fields with the condition that the peak value must be greater than or equal to the TWA value for any iteration of the model. The cumulative distributions for PE maximums in the VLCC and OLCC categories are quite similar, indicating that maximum fields are dependent on factors other than power-lines.

3.4.3 Harmonics, Home

Baseline harmonic-field data are available from the 1000-Homes and LTWC Studies [Zaffanella, 1993; Bracken et al., 1998]. The 1000-Homes Study provides total harmonic distortion (THD) data for outside (perimeter measurements) and inside (average spot measurements) locations. For both types of measurements, THD as a percentage of 60 Hz field tended to be higher for 60-Hz fields less than 1 mG. However, for 60-Hz fields above 1 mG, the THD percentage was generally in the range of 17 to 30 percent with no clear trend to lower values as the field increased. The LTWC study provided similar results for perimeter and inside spot measurements. For both types of measurements in that study, the average THD (for all measurements) was 21% with a standard deviation of about 16%.

Based on these observations, a linear relationship between harmonic and TWA fields was assumed for the model. The outside and inside baseline harmonic levels are assumed to be about 20 percent of the corresponding TWA baseline levels. A point estimate of 20% of TWA is used for harmonics in all baseline scenarios. To account for variability in the harmonics that are present, a normal distribution with a mean of 0.2 and standard deviation of 0.1 is assumed for the coefficient linking harmonic level to the total baseline field in the model. Point estimates and distributions for harmonics in the Home environment are given in Table 3.6.

3.4.4 Sources, Home

The field level for a source replaces the adjusted baseline field during the time spent using the source, provided the source field exceeds the adjusted baseline value. Field level data as a function of distance from EMF sources was extracted from the literature for numerous common sources [Gauger, 1985; Lamont et al., 1990; Zaffanella, 1993, 1996; Electric Research and Management Inc., 1997]. Point estimates for the fields at the TWA- and peak-exposure distances (see Section 3.3) were taken directly from the reported measurements or by computation from the reported values. For small appliances and tools where the field level was not given at the desired distance, the field level for the model was computed by assuming a dipole source with the field falling off as the inverse of the distance cubed ($1/r^3$). Similar sources from different studies were grouped and the mean value of the field at the TWA- and peak-exposure distances was used as the point estimate in the model. As additional magnetic field data become available for appliances, they can be included in the calculation of these point estimates.

Harmonic levels for some sources are based on reported measurements. Measured harmonic fields for appliances are available in two forms: magnetic dipole moments at 180-Hz [Zaffanella, 1996] and measured harmonic levels at specific distances [Electric Research and Management Inc., 1997]. For appliances with measured dipole moments, the harmonic level was computed as the geometric mean of the minimum and maximum dipole field at the harmonic-exposure distance assuming the field had an inverse-cubed dependence on distance. For appliances with harmonic levels measured at specific distances, the field at the model's harmonic-exposure distance was computed assuming the same inverse-cubed dependence and distance. For the remaining sources, the ratio of harmonic level to the broadband field at the surface of the appliance was multiplied times the total field at the model's harmonic-exposure distance to estimate the level of harmonics.

The point estimates for source fields are based on levels at a single distance from the source and do not account for spatial averaging over the body or for a range of separation distances during exposure to sources. Accounting for these effects results in a substantial reduction of the TWA-, peak-, and harmonic-field estimates from the point-estimate values given in Table 3-6. Using estimated fields for appliances and averaging over volumes around those appliances, Mader and Peralta ([1992]) estimated spatially averaged fields for a subset of the sources here to be from 0.1 to 0.001 times smaller than the values given in Table 3-6 (See Table 3-7). Similar estimates for fields at extremities showed reductions of from 0.1 to 0.03 times the values of the peak fields for a subset of appliances in Table 3-6 (See Table 3-7). Thus, the values for TWA, peak, and harmonic fields in Figure 3-6 represent upper bounds on exposure that might be experienced during use of these appliances.

The model is ostensibly estimating whole-body exposure. However, outputs are to be compared to model PE measurements, which represent the field only at the meter's location on the body. The TWA and, especially, the peak fields recorded by a PE meter worn at the hip may be different from those estimated by a whole-body or peak model simulation.

To accommodate various exposure levels from sources, the model performs simulations with three source factors, two of which reduce the exposure point estimates by a specified fraction. For the TWA-exposure estimation, simulations are performed with source factors of 1 (no reduction), 0.05 and 0.01 to reflect the wide range of differences between the point estimates and the spatially averaged values reported by Mader and Peralta [1992]. Similarly, for peak-field simulations, source factors are set to 1 and 0.1, to account for spatial averaging over the extremities and to 0.01 to account for peak levels measured at the hip.

To account for additional variability in exposure each source factor is (for the sake of illustration) assumed to follow a normal distribution about the point estimate with a coefficient of variation of 0.2. The normal distribution for the simulation with a source factor of 1 is truncated at 0 and at 1 to reflect the maximal nature of this estimate. The flexibility inherent in the model's use of source factors can accommodate somewhat the uncertainties associated with spatial averaging and measurement location.

Mader and Peralta [1992] combined the spatial-average fields for appliances with the estimates of average daily use to estimate the contribution of appliance fields to total

TWA exposure in the home. They concluded that appliances contributed little to whole-body exposure. Similarly, Kaune and Preece [1996] concluded that appliances contributed little to the TWA exposure of homemakers in the United Kingdom. This conclusion was based on measurements near appliances, responses to a questionnaire about usage time for appliances, and PE measurements of 50 British homemakers. They did, however, find a relationship between appliance use and the 90th percentile of PE measurements, a measure of peak exposure. Similarly, Delpizzo [1990] estimated that most appliances will not significantly affect TWA exposure because of spatial averaging and relatively short periods of use. However, electric blankets, waterbed heaters, and electric slab heaters were identified by Delpizzo as potentially significant contributors to TWA exposure.

Electric-blanket use is modeled as a special source in the Home environment. Only blankets purchased before 1992 considered. Electric blankets manufactured since about 1992 employ a new design which dramatically reduces magnetic-field levels. The field level assigned to the use of older electric blankets is based on an analysis performed by Florig and Hoberg [1990]. They estimated that the average whole-body exposure with an energized (old-style) electric blanket was 22 mG. Variability in the exposure associated with body-blanket separation, coverage, body size and other factors resulted in the 97.5th to 2.5th percentiles for average exposures having a ratio of 2.2. Based on these results, the TWA field component for electric blankets used in the model is a normal distribution with a mean of 22 mG and a standard deviation of 3.4 mG. The distribution is truncated with 1 and 39 mG as lower and upper limits, respectively. The duty cycle is assumed to be 40 percent, as estimated by Florig and Hoberg.

Electric-blanket exposure is included in the modeling of exposure only if a blanket is used and the blanket was purchased before 1992. The electric-blanket field is added in quadrature with the adjusted baseline field during the time spent using an "old" electric blanket. No source factors are applied to the electric-blanket field distributions. Since the PE meter is not worn when in bed, it is likely to be some distance from the electric blanket. This may serve to incorrectly reduce measured exposure when compared to modeled exposure.

Peak field for electric blankets was also based on the results of Florig and Hoberg [1990]. Their point estimate for the peak field at the surface of the body from an "old" electric blanket is 300 mG. The assumed distribution is normal with a coefficient of variation of 0.2 and truncation at zero and 300 mG (the point estimate).

The level of harmonics from an electric blanket depends on the type of controller it employs [Florig and Hoburg, 1990]. For "old" (pre-1992) electric blankets with resistive heating and a bi-metallic on-off controller, no harmonics are present except those associated with the power supply in the house. More recent solid-state, phase-switching controllers produce significant harmonics. For purposes of the model, blankets are assumed to employ an on-off controller, and the harmonic level is assumed to be that normally observed in residential fields away from appliances: 20 percent of the fundamental (as discussed in Section 3.3.3).

As electric technology changes, magnetic-field exposures from appliances and other sources have been, and likely will be, affected. In particular, the use of efficient, re-chargeable batteries instead of direct connection to 110-V ac mains markedly reduces magnetic-field exposures from small appliances and tools. For example, the peak magnetic field from electric shavers was reduced from about 4400 mG for older models with a power cord to less than 100 mG for battery-operated shavers [Wilson et al., 1994]. In this case, the source went from the high- to the low-exposure category in the model. Therefore, the interview for determining source use asks whether the appliances and tools in use were connected directly to 110-V ac with a power cord.

3.5 School Environment

The School environment applies to time spent at a school. The following settings are identified for the School environment:

Traditional setting with buildings surrounded by campus;
Non-traditional residential setting used for a school or day-care center; and
Non-traditional commercial setting used for school or day-care center.

Traditional school settings are considered separately from other environments. Field levels in non-traditional school settings can be ascertained from measurements and reported levels in their respective locations: e. g., Home environment levels are used for residential school and day-care centers, and levels in office buildings are used for schools in commercial locations. Leaving the school campus for a field trip or other activity constitutes entering the Other environment.

There have been limited magnetic field measurements in traditional schools. Most reports of school measurements have been restricted to one or a few schools where measurements were requested or to schools near transmission lines [EPRI, 1991; Jensen and McCourt, 1993; Zaffanella, 1993]. A comprehensive magnetic field survey of a large number of schools in California is underway [Sun et al., 1994]. Mean PE measurements in the School environment have been reported for a subsample of 106 persons from the 1000-Person Study [Zaffanella and Kalton, 1998].

3.5.1 TWA, School

3.5.1.1 Traditional Campus

Data that are available indicate that magnetic field levels in traditional schools are generally comparable to or less than those found in residential settings. Some studies reporting magnetic field measurements in schools are listed in Table 3.7. Mean field for schools within a study ranged from 0.4 mG to 1.14 mG. In most studies, no distinction was made between outside and inside measurements and no distinction was made between urban and rural schools.

The presence of transmission lines near schools elevates magnetic field levels in outside areas near schools. However, fields inside schools near transmission lines seem to be comparable with those in schools not near transmission lines [Zaffanella, 1995]. The larger size of schools compared to residences, and their increased distance from the electrical system reduce the influence of overhead power-lines on field levels, especially inside buildings.

Traditional schools do contain areas, where fields are elevated due to the presence of tools and appliances. Estimates of exposures in these areas rely on identification of the specific sources and time spent near them.

Based on these observations, the baseline categories selected for traditional schools are: rural-outside, urban-outside, inside (rural and urban), outside: transmission line, and remote (outside or inside). The remote category is intended to apply to schools with very large extended campuses where it is possible to be more than 400 m from electric distribution and transmission facilities. A similar category is included in the Other environment. The TWA baseline field levels assigned to each category are given in Table 3.8 and discussed below. No adjustments are made to these baseline levels by the model.

Rural-outside. The rural-outside baseline for the School environment is assumed to be the same as that for the Home environment: the power-line field near rural residences as measured in the 1000-Homes Study [Zaffanella, 1993]. The point estimate for these fields is 0.3 mG and the distribution is empirical, based on measurements from the 1000-Homes Study (Table 3.8). There are no factors that result in adjustments to the rural-outside baseline level in the model. However, the presence of transmission lines near a school would change the outside baseline level.

Urban-outside. The urban-outside baseline in the school environment is taken as the power-line field measured near homes in the 1000-Homes Study. If no overhead lines are present then the power-line field near UG homes is used with a point estimate of 0.43 mG and an empirical distribution from the 1000-Homes Study. If overhead lines are present then the power-line field near OLCC homes is used with a point estimate of 0.83 mG and an empirical distribution from the 1000-Homes Study (Table 3.8).

Inside. The distribution of baseline fields for inside schools is assumed to be the same for both rural and urban schools. The empirical cumulative distribution is based on PE measurements reported in the school environment for 106 persons in the 1000-Person Study [Zaffanella and Kalton, 1998]. The point estimate for TWA fields inside schools is 0.88 mG and the empirical distribution is from the 1000-Person Study data (Table 3.8).

Outside: transmission line. The field in outside locations at schools near transmission lines is based on the average power-line field near homes with nearby transmission lines. The point estimate is 2.2 mG and the empirical distribution is from the 1000-Homes Study (Table 3.8). This baseline replaces rural-outside, urban-outside: underground or urban-outside: overhead if a transmission line is within 50 m (150 feet) of the school.

Remote. The fields in remote areas away from the electrical system are assigned a point value of 0.1 mG.

3.5.1.2 Non-traditional Residential Location

Residential school settings utilize the same baseline categories as the Home environment: rural-outside, rural-inside, urban-outside: underground, urban-inside: underground, urban-outside: overhead wires, urban-inside: overhead wires, outside: transmission lines, and inside: transmission lines. Baseline field levels for these categories are assigned the same values as in the Home environment (Section 3.4.1.1 and Tables 3.3 and 3.4). Adjustments to the baseline for specific house characteristics will be made in the same manner as in the Home environment (Section 3.4.1.2 and Table 3.3b).

3.5.1.3 Non-traditional Commercial Location

For schools in commercial locations with no outside campus, TWA baseline field levels will be assigned for inside locations only. These levels will correspond to those found in the type of building in which the school is located. These most likely will be office buildings and retail settings. (See Section 3.8.1.)

3.5.2 School: Peak, School

Peak field levels outside schools are based on values reported for similar categories in other environments: that is the peak for outside: rural in the School environment is the same as for outside-rural in the Home environment. The peak field level inside schools is based on the maximum fields observed during school activity periods in the 1000-Person Study [Zaffanella and Kalton, 1998]. At least 10 percent of people had magnetic field maxima greater than about 100 mG which is used as a point estimate for maximum field. The assumed distribution is normal with a mean of 100 mG and a standard deviation of 5 mG. The peak field levels assigned to schools are given in Table 3.9.

3.5.3 Harmonics, School

Harmonic levels in four schools were in the range of 20 to 50 percent of the field level at the fundamental frequency of 60 Hz [Zaffanella, 1996]. The linear model for harmonic levels used in the School environment assumes harmonic levels are directly proportional to the resultant field level with a coefficient of 0.35 (point estimate). To account for variability in the harmonics that are present, a normal distribution with a mean of 0.35 and standard deviation of 0.1 is assumed in the model for the coefficient linking harmonic level to the total field.

3.5.4 Sources, School

Principal magnetic field sources in schools appear to be electrical supply equipment, internal wiring, external transmission and distribution lines, office equipment, and electrical appliances and tools used for instruction. Neither the presence of electrical supply equipment, such as panels and transformers, nor the location of internal wiring are easily identifiable by a questionnaire or an untrained observer. The baseline field accounts for transmission and distribution lines. Therefore the local sources of importance to our model are appliances and tools, many of which are the same as found in the Home environment.

A list of the sources found in schools that are included in this model is given in Table 3.10. Almost without exception these sources were included in the Home environment.

The same values for TWA, peak and harmonic levels are used for sources in the School environment as in the Home environment.

3.6 Work Environment

Great diversity of exposure factors and sources in the work environment and lack of extensive field on workplace environments led us to use a field level from a job exposure matrix (JEM) in place of baseline levels adjusted for various factors. By design, a JEM incorporates most of the activities and sources associated with exposures for subjects with a given job title. Therefore, source information is used to adjust the JEM exposure level only if it is unlikely to be accounted for by the JEM and it contributes to exposure levels substantially above the JEM level.

Here the magnetic field JEM used is based on two-digit job codes from the Standard Occupational Classification (SOC). This JEM was developed by Michael Yost et al. at the University of Washington from TWA magnetic field exposures in the literature [Yost et al., 1997]. The SOC is maintained by the United States Bureau of Labor Statistics and consists of several hundred job categories which combine occupations requiring similar skills or background. The categories of the SOC have no magnetic field exposure foundation but do represent a comprehensive listing of groups of similar occupations. The exposure of workers in these detailed SOC categories have not been studied in sufficient detail to construct a JEM employing the entire SOC. An abbreviated version of the 1980 SOC with 46 categories produced the JEM used by the model and the SOC job codes, descriptions and TWA exposure levels are given in Table 3.11.

To assign work exposures to subjects in the model, their reported job title is linked to an SOC code with its accompanying exposure. If a job title is not explicitly contained in the JEM, then it will be assigned an exposure from a code judged to have comparable EMF exposure based on the nature of the work environment, subject activities and the types of sources present.

Fortunately, the JEM lacks entries for only a few categories, and the broad job descriptions at the two-digit level encompass most occupations. On the other hand, the broad job categories do not permit specific high exposure jobs to be singled out.

Additional information about sources used by the subject which are unusual for the job category will be identified by questionnaire and incorporated into the model.

3.6.1 TWA, Work

The point estimate for TWA exposure for a subject's work exposure is taken as the arithmetic mean exposure for their SOC job code from the JEM. The distributions for work exposures within SOC codes are taken as log-normal based on the arithmetic mean and standard deviation from the JEM (Table 3.11).

3.6.2 Peak, Work

Peak field exposures in occupational settings are generally dependent on anecdotal scenarios and encounters with sources. For example, the 1000-Person Study estimated that for periods of work, 5 percent of persons experienced maximum fields above 200 mG and 1 percent experienced maximum fields above 400 mG [Zaffanella and Kalton, 1998]. The empirical distribution of maximum field during periods of work for the 1000-Person Study is used for all job titles in the JEM (Table 3.12a). Data on maximum fields during work periods in the 1000-Person Study were only available for the top 10 percent of values. The distribution of maximum values during a 24-hour period in the 1000-Person study was used to form the lowest 90 percent of peak values for work. This approach may actually over-estimate the peak value during work because the maximum values during a full 24-hour period were observed to be higher than those during work in the 1000-Person Study. The point estimate (mean) of the distribution for Work peak field is 84 mG.

3.6.3 Harmonics, Work

Harmonic levels in the Work environment are dependent on the magnitude of the 60-Hz field. In four occupational environments (hospitals, grocery stores, office buildings, and machine shops) the percent of harmonic distortion (180 and 360 Hz) generally decreased with increasing 60-Hz field magnitude [Zaffanella, 1996]. Harmonic levels for 60 Hz fields above 2 mG were generally between 5 and 20 percent. For modeling purposes, the harmonic levels in the work place are assumed to average 10 percent of the 60-Hz level. For purposes of the model, the broadband resultant field is considered equivalent to the fundamental 60-Hz component. Therefore, harmonic levels are assumed to be proportional to 10 percent of the mean levels reported in the JEM. The coefficient of proportionality used in the model is normally distributed with a mean of 0.10 and a standard deviation of 0.05 (Table 3.12b).

3.6.4 Sources, Work

In general, the JEM will reflect EMF sources present in the work place. However, certain sources, such as electric transmission and distribution facilities, welding machines, and other electric tools, can significantly alter exposures. Therefore, these are addressed specifically in the questionnaire and field values can be assigned for specific circumstances.

3.7 Travel Environment

Field levels assigned to periods of travel correspond to those assigned to the outside locations in the Home and School environments. The possible locations for Travel are: rural-outside, urban-outside: underground, urban-outside: overhead, and outside: transmission lines. The distributions used for the Travel environment are identical to, but generated independently from those used for the Home and School environments. For completeness, the point estimates and distributions for TWA, peak, and harmonic fields in the Travel environment are given in Table 3.13. No sources are associated with the Travel environment.

Field levels for electric vehicle travel depend on the type of vehicle: electric automobile, electric trolley, light-rail vehicle, electrical train, or subway. Unfortunately, there is inadequate information in the literature to estimate levels for all these modes of travel. In the model, magnetic field levels can be determined independently for each mode of electric vehicle travel as it is encountered.

3.8 Other Environment

The Other environment includes locations where activities take place away from home and but not at work or school or during travel. Examples of locations in this environment are grocery stores, shopping malls, medical facilities, parks, athletic and entertainment venues, and recreation facilities. Most of the locations in the Other environment have field levels comparable to those in the Home environment. For example, estimated mean fields for visitors to office buildings were 0.7 mG and for patients and visitors in hospitals 1.1 and 0.8 mG, respectively [Zaffanella, 1996]. These levels are comparable with mean TWA levels in houses. In particular, the levels for visitors in hospitals are similar to the mean level of 0.8 mG for PE measurements (excluding sleep time) in houses with underground electrical service [Zaffanella, 1996]. For purposes of the model, locations in the Other environment are assigned default field levels corresponding to the baseline level for UG houses. The only locations that are assigned higher field levels are grocery stores and areas under or adjacent to transmission lines. Remote outdoor areas such as parks and other recreation sites are assigned field levels below those found in homes. The point estimates and distributions of fields assigned to locations in the Other environment are summarized in Table 3.14, and described below.

3.8.1 TWA, Other

TWA levels assigned to most locations in the Other environment are based on the measured distribution of PE measurements (excluding sleep time) in homes with underground electrical service [Bracken et al., 1998]. This choice reflects the low fields measured in shopping areas (except grocery stores), hospitals and office buildings. The point estimate for TWA field in Other environments, except for grocery stores, near transmission lines, and remote areas, is 0.8 mG. The distribution of TWA fields in these areas is the same cumulative empirical distribution for PE in UG houses reported in the LTWC study and given in Table 3.14.

The distribution of TWA fields in grocery stores is based on a modeled distribution of exposures for customers in four grocery stores [Zaffanella, 1996]. The point estimate for TWA fields in grocery stores is 2.2 mG and the distribution is assumed to be log-normal with a mean of 2.2 and standard deviation of 0.7 (Table 3.14).

Activities in the Other environment that occur near transmission lines are assigned TWA fields characteristic of outside areas in the vicinity of transmission lines in the Home environment. These levels are characterized by a point estimate of 2.2 mG and the empirical cumulative distribution given in Table 3.14.

Activities in remote areas are assigned the same TWA field levels as those for remote areas in the School environment. These are characterized by a point estimate of 0.1 mG with no cumulative distribution.

3.8.2 Peak, Other

Peak fields in the Other environment are based on peak fields in the locations used to assign the TWA field levels for the Other environment. Peak fields in the Other environment are given in Table 3.14. The default peak field in the Other environment is the peak field from long-term fixed-location measurements in UG houses: point estimate 15 mG, distribution empirical cummulative.

The peak field in grocery stores is taken as the average of the maximum measured area field in stores: 37 mG. To allow for variation, the model assumes a normal distribution about this peak value with a coefficient of variation of 0.2. In remote areas without sources, the peak field is assumed to be the TWA value of 0.1 mG.

3.8.3 Harmonics, Other

Harmonics in the Other environment are assumed to be similar to those in the Home environment. Thus, a linear relationship is assumed between TWA and harmonic levels. The relationship is expressed by a normally distributed coefficient with a mean of 0.2 and a standard deviation of 0.1 (Table 3.14).

3.8.4 Sources, Other

In the Other environment, possible sources are the same as in the Home, School and Work environments and fields are assigned accordingly (Tables 3.6 and 3.10). For example, an electric hair clipper or electric razor could be encountered during time at a hair salon and TWA, peak and harmonic fields for those sources would be assigned to that period of time in the Other environment.

Table 3-1
Characteristics of Studies Recorded in the EMF Literature Database

Characteristic	Values
Citation #	Link to complete citation in contractor's library
Study name	Title of reference
Time period	Season/year(s) of study
Geographic location	Country, state or city (as appropriate)
Locale	Urban and/or rural
General location	Description: e. g., residence, school, electric utility, transmission line, office, etc.
Environment	Home, school, work, other
Location	Inside and/or outside
Areas characterized	Yes/no
Activities characterized	Yes/no
Sources characterized	Yes/no
Travel characterized	Yes/no
Sample target	Description: e. g., outdoor areas, welding shops, office workers, cases and controls of epidemiologic study, etc.
Type of measurements	Personal exposure, area: survey, area: long-term, source
Age of subjects	Years
Reference group	Preschool, children, adults, seniors
Sample method	Random, targeted, convenience, volunteers
Field characteristic(s)	Peak (single axis), resultant (3-axis) magnetic field, harmonics, etc.
Instrument	Description: model, manufacturer
Sampling interval	Seconds between measurements
Sampling duration	Length of measurement period: hours, days
Sample size	Number of locations, subjects, sources, etc.
Field type	Magnetic and/or electric field
Industry type designated	Yes/no
Job category designated	Yes/no
Summary measure	Mean, time-weighted average, peak, visual plots, etc.

Table 3-2
Field Level Categories for Sources

Source Field for TWA Exposure, mG		Source Field for Peak Exposure, mG	
Low	≤ 10	Low	≤ 100
Medium	10 - 100	Medium	100 - 1000
High	≥ 100	High	≥ 1000

Table 3-3
Baseline TWA Field Levels for the Home Environment: a) Baseline; b) Adjustments

a) Baseline field levels

Location	Description	Point Estimate, mG	Distribution*	Combinatorial Formula	References
Rural outside	Power-line field for rural houses	0.3	Empirical cumulative†	Outside baseline for rural houses	Zaffanella, 1993
Rural inside	PE mean for VLCC houses	0.6	Empirical cumulative†	Inside baseline for rural houses	Bracken et al., 1998
Urban outside: underground	Power-line field for UG houses	0.43	Empirical cumulative†	Outside baseline for urban UG houses	Zaffanella, 1993
Urban inside: underground	PE mean for UG houses	0.6	Empirical cumulative†	Inside baseline for urban UG houses	Bracken et al., 1998
Urban outside: overhead lines	Power-line field for OLCC houses	0.83	Empirical cumulative†	Outside baseline for urban houses with overhead service	Zaffanella, 1993
Urban inside: overhead lines	PE mean for OLCC houses	1.2	Empirical cumulative†	Inside baseline for urban houses with overhead service	Bracken et al., 1998
Outside: transmission line	Power-line field for houses with transmission line nearby	2.2	Empirical cumulative†	Replaces outside baseline for urban or rural houses	Zaffanella, 1993
Inside: transmission line	Average spot measurements for houses with transmission line nearby	2.3	Empirical cumulative†	Replaces inside baseline for urban or rural houses	Zaffanella, 1993

b) Adjustments to baseline field levels

Location	Description	Point Estimate, mG	Distribution*	Combinatorial Formula	References
Kitchen	Higher fields exhibited in kitchen	0.2	TLOGNORM (0.2, 0.1,0,1)	Added to inside baseline	Zaffanella, 1993
House size: >1800 sf	Decrease in mean field associated with larger houses	0.3	TLOGNORM (0.3, 0.1,0,0.8)	Subtracted from inside baseline; minimum inside baseline = 0.1 mG	Zaffanella, 1993
Connected to well	Houses served by a well exhibit lower fields	0.2	TLOGNORM (0.2, 0.1,0,0.4)	Subtracted from inside baseline of rural houses; minimum inside baseline = 0.1 mG.	Zaffanella, 1993
House age: > 30 yr	Older houses exhibit higher fields	0.2	TLOGNORM (0.2, 0.1,0,0.8)	Added to inside baseline in quadrature	Zaffanella, 1993
Multi-family dwelling	Multi-family dwellings exhibit higher fields	0.3	TLOGNORM (0.3, 0.2,0,1.3)	Added to inside baseline in quadrature	Zaffanella, 1993
2-prong outlets present	Houses with 2-prong plugs exhibit higher fields	0.2	TLOGNORM (0.2, 0.1,0,0.7)	Added to inside baseline in quadrature	Zaffanella, 1993
Electric ceiling heat	Electric ceiling heat exhibit higher fields	0.3	TNORMAL (0.3, 0.2,0,1.3)	Added to inside baseline in quadrature	Zaffanella, 1993

* Distributions are given in terms of @Risk functions from *Guide to Using @RISK* (Palisade Corporation, Newfield NY, 1997)

Empirical cumulative distribution:	CUMUL(min, max, {x_1, ..., x_n}, {p_1, ..., p_n}) where min is the minimum value of the empirical parameter; max is the maximum value of the parameter; and x_1, ..., x_n are the parameter values for the cumulative fractions p_1, ..., p_n
Normal distribution:	NORMAL(μ, σ) where μ is the mean and σ is the standard deviation of the corresponding normal distribution
Log-normal distribution:	LOGNORM(μ, σ) where μ is the arithmetic mean and σ is the standard deviation of the corresponding log-normal distribution
Truncated normal distribution:	TNORMAL(μ, σ, min, max) where μ is the mean, σ is the standard deviation of the corresponding normal distribution, min is the minimum value of the parameter, and max is the maximum value of the parameter.
Truncated lognormal distribution:	TLOGNORM(μ, σ, min, max) where μ is the arithmetic mean of the corresponding log-normal distribution, and σ is the standard deviation of the corresponding lognormal distribution, min is the minimum value of the parameter, and max is the maximum value of the parameter.

† Empirical cumulative distributions are given in Table 3.4

Table 3-4
Empirical Cumulative Distributions for Baseline Field Levels in the Home Environment

Baseline	Description	@Risk Distribution	Source
Rural outside	Rural power-line fields	CUMUL(.02, 2.6,{.05, .1, .2, .4, .8, 1.4, 2.5},{ .05, .25, .5, .75, .9, .95, .99})	Zaffanella, 1993
Rural inside	PE for VLCC houses	CUMUL(.1, 1.3,{ .1, .3, .5, .7, 1.3},{ .05, .25, .5, .75, .95})	Bracken et al., 1998
Urban outside: underground	Power-line fields for UG houses	CUMUL(.02, 1.8,{.05, .1, .3, .6, 1.2},{ .05, .25, .5, .75, .95})	Zaffanella, 1993
Urban inside: underground	PE for UG houses	CUMUL(.1, 1.8,{ .1, .3, .6, .8, 1.3},{ .05, .25, .5, .75, .95})	Bracken et al., 1998
Urban outside: overhead lines	Power-line fields for OLCC houses	CUMUL(.08, 3.0,{ .1, .2, .6, 1.4, 2.2},{ .05, .25, .5, .75, .95})	Zaffanella, 1993
Urban inside: overhead lines	PE for OLCC houses	CUMUL(.2, 3.9,{ .28, .5, .8, 1.7, 3.5},{ .05, .25, .5, .75, .95})	Bracken et al., 1998
Outside: transmission lines	Power-line fields for houses near transmission lines	CUMUL(.05, 12,{ .1, .3, .9, 2.1, 10.3},{ .05, .25, .5, .75, .95})	Zaffanella, 1993
Inside: transmission lines	Average spot measurements for houses near transmission lines	CUMUL(.1, 12,{ .3, .5, 1.2, 1.9, 9.5},{ .05, .25, .5, .75, .95})	Zaffanella, 1993

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3.

Table 3-5
Baseline Peak Field Levels for the Home Environment

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Rural: outside	Long-term fixed-location maximum for VLCC houses	23	Empirical cumulative[1]	Maximum: ≥ TWA value for period	Bracken et al., 1994
Rural: inside					
Urban: outside	Long-term fixed location maximum for OLCC houses	15	Empirical cumulative[2]	Maximum: ≥ TWA value for period	Bracken et al., 1994
Urban: inside					

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3.

1 CUMUL(1, 50,{1.3, 4, 6, 11, 27},{ .05, .25, .5, .75, .95})

2 CUMUL(1, 70,{ 1.4, 3, 8, 17, 51},{ .05, .25, .5, .75, .95})

Table 3-6
TWA and Peak Distances and Field Levels and Harmonic Field Levels for Sources in the Home Environment

Category	Item (electric-powered)	TWA Distance, m	TWA Field, mG	Peak Distance, m	Peak Field, mG	Harmonic Field, mG	References
Yard	Blower	0.3	56	0	1500	2	2
	Clipper, hedge	0.3	44	0	1200	2	2
Kitchen	Can opener	0.3	190	0	8400	2	1, 2, 3
	Coffee grinder	0.3	16	0	420	4	2
	Food processor	0.3	12	0	450	4	1, 2, 3, 5
	Fry pan broiler	0.3	15	0	390	0	2
	Ice cream maker	1	4	0	4000	0.5	2
	Knife sharpener	0.3	53	0	1400	0.2	2
	Knife, electric	0.3	90	0	2400	2	2
	Microwave oven	1	7	0	2400	2	1, 2, 3
	Mixer, electric hand	0.3	27	0	4000	0.21	1, 2, 5
	Mixer, tabletop	0.3	30	0	1500	0.2	1, 2
	Range	0.3	21	0	640	0	1, 2, 3
	Slicer, meat	0.3	5	0	135	0.2	2
Household	Air cleaner	1	3	0.3	111	0.02	2
	Broom, electric	0.3	11	0	1100	2	2
	Fluorescent lamp	0.3	57	0	1900	2.8	1
	Heater	1	3	0	710	0.05	1, 3, 5
	Iron, clothes	0.3	2	0	140	0.1	2, 3, 5
	Sewing machine	0.3	7	0	190	1	2
	Vacuum	0.3	51	0	3000	8.3	1, 2, 5
Personal care	Hair dryer, gun-type	0.3	1	0	180	0.2	1, 2, 6
	Hair dryer, hood type	0.3	63	0	10000	13	1, 2
	Heating pad	0	33	0	33	1	2
	Shaver (with power cord)	0.1	200	0	6100	46	1, 2, 5, 6
	Shaver (battery-powered)	0.1	1	0	70	0.2	6

Category	Item (electric-powered)	TWA Distance, m	TWA Field, mG	Peak Distance, m	Peak Field, mG	Harmonic Field, mG	References
Personal care	Spa, bathtub	0.3	45	. 0	1200	6	2
Entertainment	Aquarium pump	1	5	0	4000	0.01	3, 4
Office	Copy machine	0.3	50	0.1	1400	3	4
	Fan	1	4	0.3	170	0.1	4
	Fluorescent light	1	5	0.3	180	0.1	4
	Pencil sharpener	0.3	340	0.1	9200	11	4
	Projector, overhead	1	5	0.1	4700	0.14	2, 4
	Typewriter, electric	0.3	4	0	120	0.01	2
	Uninteruptable power supply	1	11	0.3	420	0.4	4
	Video display terminal	1	0	0.02	115	0.6	5
Tools	Drill bit sharpener	0.3	180	0	4800	1.5	2
	Drill press	0.3	63	0.1	1700	1	2, 4
	Drill, portable	0.3	56	0	4400	3	2, 5
	Engraver	0.3	27	0	740	1.5	2
	Grinder	0.3	100	0.1	2800	6.6	2, 4
	Painter, airless	0.3	190	0	5700	8	2, 5
	Router, hand	0.3	67	0	1800	1.5	2
	Sander, hand	0.3	80	0.1	2200	1.3	2, 4
	Saw, circular	0.3	55	0	4200	10	1, 2, 5
	Saw, portable jig	0.3	43	0	1200	2	2, 5
	Saw, reciprocating	0.3	18	0	4300	2	1, 2
	Saw, table	0.3	10	0	230	1	1
	Soldering gun/iron	0.3	300	0	14000	0.34	1, 2, 5
Equipment	Air compressor	1	6	0.3	210	0.02	4
	Welder power supply	1	12	0.3	440	0.69	4

1. J. Gauger. *Household Appliance Magnetic Field Survey IEEE Transactions on Power Apparatus and Systems.* Vol. 104, pp. 2436-2445 (1985).

2. J.W. Lamont, G.G. Hillesland, and A.J. Mitchell. *A Composite Exposure Index for Magnetic Field Exposure.* Iowa State University, Ames, IA 1990.

3. L.E. Zaffanella. *Survey of Residential Magnetic Field Sources.* EPRI TR-102759-V1, Project 3335-02. Electric Power Research Institute, Palo Alto, CA 1993.

4. L.E. Zaffanella. *Environmental Field Surveys: EMF RAPID Program Engineering Project #3.* Enertech Consultants, Lee, MA 1996.

5. Electric Research and Management, Inc. *EMF RAPID Program Engineering Projects: Project 1-Development of Recommendations for Guidelines for Field Source Measurement.* Electric Research and Management, Inc., State College, PA 1997.

6. Wilson et al., 1994

Table 3-7
Ratio of Whole-body Average to Point-estimate Fields for Selected Appliances

Source	TWA Whole-body Field, mG			Peak Exposure Field, mG		
	Point Estimate	Spatial Average[1]	Ratio Ave./Pt.	Point Estimate	Extremity[1]	Ratio Ave./Pt. est
Can opener	190	0.8	0.004	8400	606	0.072
Food processor/blender	12	0.092	0.008	450	56	0.124
Microwave oven	7	0.71	0.101			
Hand mixer	27	0.22	0.008	4000	162	0.041
Range	21	0.087	0.004			
Fluorescent lamp	57	0.13	0.002			
Heater	3	0.2	0.067			
Clothes iron	2	0.014	0.007	140	6.7	0.048
Vacuum	51	0.6	0.012			
Hair dryer	1	0.15	0.15	180	120	0.667
Shaver	200	0.21	0.001	6100	169	0.028
Fan	4	0.14	0.035			
Fluorescent light	5	0.11	0.022			
Drill	56	0.16	0.003	4400	127	0.029
Hand saw	55	0.45	0.008	4200	325	0.077

[1] Mader and Peralta, 1992

Table 3-8
Reported Magnetic Field Levels in Schools

Geographic Location	Number of Schools	Number of Students	Measurement Type*	Mean	Geometric Mean	Reference
Not specified	14 5	— —	PIT PIT	1.04[1] 1.14[2]		Silva and Marshall, 19??
Ontario	79	—	PIT	0.82	0.33	Sun et al., 1994
California and Massachusetts	4	—	PIT	0.83	0.47‡	Zaffanella, 1996
San Francisco, CA area	1 1	18 13	PE PE	0.4 0.9		Bracken et al., 1997
U.S.	Not given	106 persons	PE	0.88	0.69	Zaffanella and Kalton, 1998

* PE = Personal Exposure; PIT = Point-in-time
‡ Median

1 No transmission lines nearby
2 Transmission lines nearby

Table 3-9
Baseline TWA Field Levels for the School Environment

Location	Description	Point Estimate	Distribution*	Combinatorial Formula	Reference
Rural-outside	Power-line field for rural houses	0.3	Empirical cumulative[1]	Baseline	Zaffanella, 1993
Urban-outside: underground	Power-line field for UG houses	0.43	Empirical cumulative[2]	Baseline	Zaffanella, 1993
Urban-outside: overhead	Power-line filed for OLCC houses	0.83	Empirical cumulative[3]	Baseline	Zaffanella, 1993
Inside	PE from 1000-Person Study	0.88	Empirical cumulative[4]	Baseline	Zaffanella and Kalton, 1998
Outside: transmission line	Power-line field for houses near transmission line	2.2	Empirical cumulative[5]	Replaces outside baseline (urban/rural, underground/ overhead)	Zaffanella, 1993
Remote	Outside or inside in area away from electrical system	0.1	Point estimate only	Baseline	Hutchinson, 1992

* Distributions are given in terms of @ Risk functions. See footnote to Table 3-3.

1 CUMUL(.02, 2.6,{.05, .1, .2, .4, .8, 1.4, 2.5},{ .05, .25, .5, .75, .9, .95, .99})
2 CUMUL(.02, 1.8,{.05, .1, .3, .6, 1.2},{ .05, .25, .5, .75, .95})
3 CUMUL(.1, 1.8,{ .1, .3, .6, .8, 1.3},{ .05, .25, .5, .75, .95})
4 CUMUL (0.0, 6.6, {.09, .2, .3, .4, .7, 1.1, 1.6, 1.9, 3.2}, {.01, .05, .1, .25, .5, .75, .9, .95, .99})
5 CUMUL(.05, 12,{ .1, .3, .9, 2.1, 10.3},{ .05, .25, .5, .75, .95})

Table 3-10
Baseline Peak Field Levels for the School Environment

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Rural-outside	Long-term fixed location maximum for VLCC houses	15	Empirical † cumulative	Maximum ≥ TWA value for period	Bracken et al., 1994
Urban-outside	Long-term fixed location maximum for OLCC houses	10	Empirical † cumulative	Maximum ≥ TWA value for period	Bracken et al., 1994
Inside	PE from 1000-Person Study	100	Normal (100,5)	Maximum ≥ TWA value for period	Zaffanella and Kalton, 1998

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3.

† See Table 3-5 for empirical distributions and comments.

Table 3-11
TWA and Peak Distances and Field Levels and Harmonic Field Levels for Sources in the School Environment

Category	Item (electric-powered)	TWA Distance, m	TWA Field, mG	Peak Distance, m	Peak Field, mG	Harmonic Field, mG	References
Classroom	Aquarium pump	1	5	0	4000	0.01	3, 4
	Fan	1	4	0.3	170	0.1	4
	Fluorescent lamp	0.3	57	0	1900	2.8	1
	Heater	1	3	0	710	0.05	1, 3, 5
	Pencil sharpener	0.3	340	0.1	9200	11	4
	Projector, overhead	1	5	0.1	4700	0.14	2, 4
	Typewriter, electric	0.3	4	0	120	0.01	2
	Video display terminal	1	0	0.02	115	0.6	5
Home economics classroom	Food processor	0.3	12	0	450	4	1, 2, 3, 5
	Microwave oven	1	7	0	2400	2	1, 2, 3
	Mixer, electric hand	0.3	27	0	4000	0.21	1, 2, 5
	Mixer, tabletop	0.3	30	0	1500	0.2	1, 2
	Range	0.3	21	0	640	0	1, 2, 3
	Iron, clothes	0.3	2	0	140	0.1	2, 3, 5
	Sewing machine	0.3	7	0	190	1	2
Other areas	Hair dryer, gun-type	0.3	1	0	180	0.2	1, 2, 6
	Vending machine†						
Office	Copy machine	0.3	50	0.1	1400	3	4
	Fluorescent light	1	5	0.3	180	0.1	4
	Uninteruptable power supply	1	11	0.3	420	0.4	4
Shop classroom	Drill press	0.3	63	0.1	1700	1	2, 4
	Drill, portable	0.3	56	0	4400	3	2, 5
	Engraver	0.3	27	0	740	1.5	2
	Grinder	0.3	100	0.1	2800	6.6	2, 4
	Router, hand	0.3	67	0	1800	1.5	2
	Sander, hand	0.3	80	0.1	2200	1.3	2, 4

Category	Item (electric-powered)	TWA Distance, m	TWA Field, mG	Peak Distance, m	Peak Field, mG	Harmonic Field, mG	References
Shop classroom	Saw, circular	0.3	55	0	4200	10	1, 2, 5
	Saw, portable jig	0.3	43	0	1200	2	2, 5
	Saw, reciprocating	0.3	18	0	4300	2	1, 2
	Saw, table	0.3	10	0	230	1	1
	Soldering gun/iron	0.3	300	0	14000	0.34	1, 2, 5
	Air compressor	1	6	0.3	210	0.02	4
	Welder power supply	1	12	0.3	440	0.69	4

† Not in Home environment.

1. J. Gauger. "Household Appliance Magnetic Field Survey," *IEEE Transactions on Power Apparatus and Systems*. Vol. 104, pp. 2436-2445 (1985).

2. J.W. Lamont, G.G. Hillesland, and A.J. Mitchell. *A Composite Exposure Index for Magnetic Field Exposure*. Iowa State University, Ames, IA 1990.

3. L.E. Zaffanella. *Survey of Residential Magnetic Field Sources*. EPRI TR-102759-V1, Project 3335-02. Electric Power Research Institute, Palo Alto, CA 1993.

4. L.E. Zaffanella. *Environmental Field Surveys: EMF RAPID Program Engineering Project #3*. Enertech Consultants, Lee, MA 1996.

5. Electric Research and Management, Inc. *EMF RAPID Program Engineering Projects: Project 1-Development of Recommendations for Guidelines for Field Source Measurement*. Electric Research and Management, Inc., State College, PA 1997.

6. Wilson et al., 1994

Table 3-12
Magnetic Field Job Exposure Matrix by SOC Job Code

Job Codes	N	Group TWA Exposure, mG				Job Titles
		Arithmetic		Geometric		
		Mean	Std. Dev.	Mean	Std. Dev.	
1100	15	1.8	0.6	1.7	1.4	officials and administrators, public administration
1213[2]	102	1.9	1.9	1.3	2.0	officials and administrators, other
1400	70	1.4	1.2	1.1	1.8	management related occupations
1600	211	2.5	4.1	1.7	2.1	engineers, surveyors and architects
1700	31	2.1	2.4	1.4	2.1	computer, mathematical, and operations research occupations
1800	14	1.3	0.8	0.9	1.9	natural scientists
1900	10	1.0	0.4	0.9	1.4	social scientists and urban planners
2000	10	1.2	0.6	1.1	1.4	social, recreation, and religious workers
2100	1	2.1	0.5	2.0	1.3	lawyers and judges
2200	25	1.4	1.0	1.1	1.8	teachers; college, university and other postsecondary institution
2300	57	1.5	2.6	0.9	2.0	teachers, except postsecondary institution
2600	10	1.8	0.9	1.6	1.5	physicians and dentists
2800	2	1.1	4.5	0.7	1.6	other health diagnosing and treating practitioners
2900	14	1.0	1.0	0.8	1.9	registered nurses
3200	9	3.2	3.1	2.2	2.1	writers, artists, performers, and related workers
3300	6	2.7	1.5	2.0	1.6	editors, reporters, public relations specialists, and announcers
3600	28	1.9	4.9	1.1	2.2	health technologists and technicians
3700	31	3.4	2.6	2.5	2.1	engineering and related technologists and technicians
3800	3	1.7	2.6	1.0	3.6	science technologists and technicians
3900	28	2.4	3.0	1.6	2.0	technicians, except health, engineering, and science
4000	25	2.7	2.5	2.1	1.7	supervisors; marketing and sales occupations
4100	14	1.2	1.0	1.0	1.7	insurance, securities, real estate, and business service sales
4200	40	1.9	1.0	1.6	1.6	sales occupations, commodities, except retail
4300	28	2.3	1.4	1.9	1.7	sales occupations, retail
4500	9	1.6	1.4	1.0	1.9	supervisors: administrative support occupations, including clerical
4647[2]	172	2.2	3.5	1.4	2.1	administrative support occupations, including clerical

Job Codes	N	Group TWA Exposure, mG				Job Titles
		Arithmetic		Geometric		
		Mean	Std. Dev.	Mean	Std. Dev.	
5100	24	1.7	1.0	1.5	1.7	protective service occupations
5200	69	4.0	14.0	1.6	3.0	service occupations, except private household and protective
5500	18	2.7	5.4	1.2	3.6	farm operators and managers
5600	32	2.8	6.3	1.2	3.3	other agricultural and related occupations
5700[3]	9	24.8	77.0	7.6	4.7	forestry and logging occupations
6100	158	3.2	3.5	2.2	2.1	mechanics and repairers
6400	276	20.8	80.6	4.6	3.2	construction trades
6500	3	0.6	0.2	0.6	1.3	extractive occupations
6800	87	3.8	15.8	1.8	2.5	precision production occupations
6900	51	14.3	22.4	7.8	2.8	plant and system operators
7100	12	2.2	3.2	1.6	1.8	supervisors: production occupations
7374[2]	14	8.0	6.8	6.3	2.0	machine setup operators
7576[2]	24	2.1	1.6	1.6	1.9	machine operators and tenders
7700	51	16.9	36.4	7.1	3.0	fabricators, assemblers, and hand working occupations
7800	4	2.3	2.9	1.2	2.7	production inspectors, testers, samplers, and weighers
8100	7	5.7	6.1	3.9	2.4	supervisors: transportation and material moving occupations
8200	46	2.4	7.2	1.3	2.6	transportation occupations
8300	25	2.2	1.7	1.5	1.7	material moving occupations, except transportation
8700	31	2.1	2.1	1.5	1.9	handlers, equipment cleaners and laborers
9100	4	1.7	0.6	1.6	1.4	military occupations

1 Yost et al., 1997

2 Job codes 1213, 4647, 7374, and 7576 were created by combining the two major group numbers which the group encompasses; e.g., group 1213 denotes all codes beginning with a 12 or 13.

3 These data are based solely on the Floderus et al., 1996.

Table 3-13
Baseline Peak and Harmonic Field Levels for the Work Environment

a) Peak

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	Reference
Work	Maximum field during work for 1000-Person Study	84	Empirical Cumulative [1]	Maximum > TWA	Zaffanella and Kalton, 1998

1 CUMUL(5, 1700,{20, 40, 50, 100, 120, 210, 400, 1000} , {.05, .25, .5, .75, .90, .95, .99, .995})

b) Harmonic

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	Reference
Work	Fraction of TWA field	0.1	NORMAL(0.1, 0.05)	Multiply TWA field by sampled fraction	Zaffanella, 1996

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3.

Table 3-14
Baseline TWA, Peak and Harmonic Field Levels for the Travel Environment

a) TWA fields

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Rural-outside	Power-line field for rural houses	0.3	Empirical cumulative[1]	Baseline for rural travel	Zaffanella, 1993
Urban-outside: underground	Power-line field for UG houses	0.43	Empirical cumulative [2]	Baseline for urban travel in areas with UG	Zaffanella, 1993
Urban-outside: overhead	Power-line field for OLCC houses	0.83	Empirical cumulative [3]	Baseline for urban travel in areas with OH	Zaffanella, 1993
Outside: transmission lines	Power-line field for houses with transmission line nearby	2.2	Empirical cumulative [4]	Baseline for travel in areas with transmission line nearby	Zaffanella, 1993

1 CUMUL(.02, 2.6,{.05, .1, .2, .8, 1.4, 2.5} , {.05, .25, .5, .75, .95, .99})
2 CUMUL(.05, 1.65,{.09, .2, .4, .81, 1.5} , {.05, .25, .5, .75, .95})
3 CUMUL(.08, 3.0,{.1, .2, .6, 1.4, 2.2} , {.05, .25, .5, .75, .95})
4 CUMUL(.05, 12,{.1, .3, .9, 2.1, 10.3} , {.05, .25, .5, .75, .95})

b) Peak fields

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Rural-outside	Long-term fixed-location maximum for VLCC houses	10	Empirical cumulative[1]	Maximum: ≥TWA value for period	Bracken et al., 1994
Urban-outside	Long-term fixed-location maximum for OLCC houses	15	Empirical cumulative[2]	Maximum: ≥ TWA value for period	Bracken et al., 1994

1 CUMUL(1, 50,{1.3, 4, 6, 11, 27},{.05, .25, .5, .75, .95})
2 CUMUL(1, 70,{1.4, 3, 8, 17, 51},{.05, .25, .5, .75, .95})

c) Harmonic fields

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Travel	Fraction of TWA field	0.2	Normal (0.2, 0.1)	Multiply TWA field by fraction	

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3

Table 3-15
Baseline TWA, Peak, and Harmonic Field Levels for the Other Environment

a) TWA

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Default	PE in UG houses	0.6	Empirical cumulative[1]	Default baseline in the Other environment	Bracken et al., 1998
Grocery stores	Modeled customer exposures	2.2	LOGNORM (2.2, 0.7,0.1,4.3)	Baseline for grocery stores	Zaffanella, 1996
Transmission lines	Power-line field for houses with transmission line nearby	2.2	Empirical cumulative[2]	Baseline for areas near transmission lines	Zaffanella, 1993
Remote	Outside or inside in area away from electrical system	0.1	Point estimate only	Baseline for remote areas	Hutchinson, 1992

1 CUMUL(0.2, 3.3,{0.2, 0.3, 0.7, 0.9, 2.3},{.05, .25, .5, .75, .95})
2 CUMUL(.05, 12,{.1, .3, .9, 2.1, 10.3},{.05, .25, .5, .75, .95})

b) Peak

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Default	Long-term fixed-location for OLCC houses	15	Empirical cumulative[1]	Maximum ≥ TWA value for period	Bracken et al., 1994
Grocery stores	Average maximum measured area field	37	Normal (37,2)	Maximum	Zaffanella, 1996
Transmission lines	Long-term fixed-location for OLCC houses	15	Empirical cumulative[1]	Maximum ≥ TWA value for period	Bracken et al., 1994
Remote	Outside or inside away from electrical system	0.1	Point estimate only	Maximum	Hutchinson, 1992

[1] CUMUL(1, 70,{ 1.4, 3, 8, 17, 51},{ .05, .25, .5, .75, .95})

c) Harmonic fields

Location	Description	Point Estimate (mG)	Distribution*	Combinatorial Formula	References
Other	Fraction of TWA field	0.2	NORMAL(0.2, 0.1)	Multiply TWA field by fraction	

* Distributions are given in terms of @Risk functions. See footnote to Table 3-3

4

SUBJECT INTERVIEWS

4.1 Introduction

Time-activity information required from a subject consists of several types: subject attributes, time spent in exposure environments, attributes of the environments that describe baseline exposure, activities in the environments that might contribute to EMF exposure, and sources in the environments that might contribute to EMF exposure. Since it is unlikely that a naive subject would be aware of specific activities and sources relevant to EMF exposure, an interview, rather than self-administered questionnaire was used to obtain the information from a subject. The interview is specifically structured to elicit the inputs to the exposure model from the interviewee. The interview should provide an overall estimate of time spent in each environment, an estimate of time for any source present or activity performed in the environment, and information that modifies the baseline exposure in the environment.

Preliminary unstructured interviews with acquaintances indicated that:

1) It was difficult for respondents to give an accurate breakdown of time spent in the major environments. When time in the general environments were estimated by the subject at first, a simple follow-up diary indicated the estimates were not very accurate. Furthermore, the time from the general environment estimates did not add to the total time and the respondent was forced to correct them.

2) Presenting long lists of source-related activities for each environment, out of the context of the flow of events of the previous day, made the interview boring for the interviewer and the respondents. This could lead to inaccurate responses.

3) Getting respondents to provide the exact number of minutes for EMF-related activities was probably not realistic. The respondents wanted to answer in more general intervals—e.g., less than a minute, about 5 minutes, 5 or 10 minutes, etc. The midpoints can be used for input when using this interval approach.

Based on these preliminary observations, we proceeded to develop an interviewer-administered protocol, about 45 minutes in length, that elicits information on model input variables pertaining to a target day prior to the interview. The purpose of the interview is to provide retrospective input data for a period when the respondent was wearing the EMDEX II.

Another application for the interview can be to provide input data for a so-called "typical" day, a different kind of problem which requires a related but different strategy. The target day approach allows the interview to exit some question series when they don't apply to that day. On the other hand, getting at typical exposures usually means having to be comprehensive and be concerned about whether the respondent can really "average" in the way necessary to accurately portray a typical day.

A questionnaire that could be adapted to estimate a subject's exposure on a typical day was developed by Kaune and Preece [1996] for a study examining magnetic field exposure to residential appliances. Their study interview asked about the average time spent in specific areas of the home and the time spent using various appliances, rather than chronologically recording a subject's day. The subject was asked whether they spent time in a given room (environment) during the previous month and if so, how much time was spent there on average during weekdays and weekends. When combined with estimates of the number of days of each type for a given period, the result is an estimate of time in rooms (environments) for a typical day.

Kaune and Preece assessed appliance usage in a similar manner by ascertaining average durations of use rather than use during specific times of day. Specifically, subjects were asled whether they used various appliances and if so, what its age was, the average amount of time per use, and how frequently they used it during the week. In the case of appliances that are always on, such as clocks, the subject was asked its age and how much time per day the subject spent at various distances from the appliance. The information provided was used to estimate exposure based on field levels at selected distances from the appliances and estimates of the time the subject typically spent at those distances.

4.2 Interview Format

To obtain the subject information efficiently, the interviews were constructed as follows:

4.2.1 Introduction

Usually, the introductory remarks in interviews would be limited to giving respondents the rationale for the interview. However, in this case, with the need for accurate recall over a 24-hour period, the introduction was expanded to include a step-by-step description of the interview process. The respondents are told that the interviewer and subject will discuss the subject's previous day, paying special attention to activities related to use of electrical appliances/equipment or proximity to other sources. They also discuss the places the subject spent time during the previous day, and so on.

4.2.2 24-hour Activity Diary

Two types of diary were developed for use in the pilot study: a retrospective 24-hour diary constructed through an interview and a concurrent diary kept by the subject.

Retrospective diary

The respondents complete a diary of their day, prompted by the interviewer using chronological subject activities to assist in recall of the time period in question. Thus, the interview and resulting diary have a time-based sequential format, similar to one used during a previous study of 24-hour activities for adults and children [Wiley et al., 1991a, b]. This flow-of-events format seems to work better and faster than questions that take activities and locations out of a temporal context.

Starting with the time the meter was deployed (or other specific time) on the previous day and continuing until the meter is retrieved, the interviewer asks for and records the following information for each activity:

1) the time the activity began;
2) what the activity was (pre-coding is difficult due to the diversity of activities, so brief verbatim accounts are recorded);
3) where the activity occurred (home, school, work, travel, or other), whether indoors or outdoors, and whether the location was urban, suburban or rural;
4) the use of any electrical appliances or equipment during the activity, including the nature of the sources and time estimates if the sources are contained on a predetermined list of sources of interest (time intervals rather than a point estimate are used for the time estimate); and
5) the time the activity ended.

By aggregating the information about activities over the 24-hour period, we obtain estimates of time in environments, whether a source was present or activity occurred and, if so, for how long.

The interviewer keeps 'bookmarks" as the diary is being completed. These consist of reminders of which environments were visited during the day and which of the precoded source-related activities were performed during the day. This information is used to guide portions of the post-diary section of the interview.

<u>Concurrent diary</u>

For the concurrent activity diary the subjects use pre-printed forms to record the times and locations of their activities and any sources that were used during the activity. Some of the information on the concurrent diary parallels the retrospective diary, including: start and end times, a description of the activity, where it took place (e.g. home-kitchen, home-other, workplace, etc. and inside, outside or both), and any electrical appliances that were used. The diaries are reviewed with the interviewer during the follow-up interview.

4.2.3 Post-diary Questions

Following completion of the 24-hour diary, supplementary information is obtained. The interviewer collects information about the participant (age, employment status and job title, etc.), and, where applicable, the work, home, school and other environments. Information collected during this portion of the interview supplements the activity-diary data.

The interview questions use lists of possible EMF activities/sources keyed to the environments where the respondents actually spent time based on their activity diary. For example, the interviewer will explain that: "Now I'd like to go through some lists of appliances and equipment so I can be sure we didn't miss anything important ..." or "Starting with the time you spent at school (or work or home) ...". Then the interviewer gives the respondent the prepared lists of sources for the environment and reviews the list with them. This review may prompt the respondent to recall new activities, which can be recorded along with their associated descriptive information. This provides an opportunity to correct and enhance the information previously obtained during construction of the diary.

Additional enquiries are made to provide information that adjusts the baseline exposure levels by addressing attributes of the home environment (age and size of house, presence of electric ceiling heat, etc.), the school environment (e.g., presence of power lines), and the nature of other environments occupied by the respondent. Since we already know where the respondent spent his/her time, it is only necessary to ask about attributes of those those occupied environments.

If the respondent worked on the day at issue, the interviewer asks about the applicable industry and respondent's occupation. Modified questions from the 1990 United States Census were used to produce two-digit occupation codes that are linked to the job exposure matrix (JEM) described in Section 3.6. Both the 1990 Census and JEM occupation categories are based on the 1980 Standard Occupational Classification so assigning subjects to JEM categories was straightforward. Specific questions are also asked about the work environment to confirm or supplement information contained in the 24-hour activity diary.

4.2.4 Interviewer Observations

The interviewer completes a form that records attributes of the residence, such as the type of residence (single-family, duplex or apartment), the presence of overhead lines, and the type of area (urban, suburban, or rural). If the final part of the interview is not conducted at the subject's residence, then the subject is asked to respond to these questions.

4.2.5 Superfluous Information

There is a natural linkage between activities, environment, and time estimates that serves well in generating inputs for the exposure model. However, the structure presented here collects information on some activities that are unrelated to EMF exposures. It would be inefficient if it was necessary to code such information.

However, we can ignore that which is not relevant to the EMF model. Any inefficiencies associated with collecting superfluous data are more than overcome by the ease with which the interview flows due to the logical structure of the questions.

4.3 Sample Interview

Two interview formats were used during the pilot study. The first employed a retrospective construction of the 24-hour activity diary. The second format was used after subjects had kept their own concurrent activity diary during the 24 hours that they wore an exposure meter. The interview portion of the protocol was performed 24 to 36 hours after measurements. Eighteen of the 20 interviews were conducted in the home of the respondent. The two other interviews were done at the respondent's workplace. In all cases, the respondents were interviewed in private, usually in the living room of the respondent's home. The average length of the interview was approximately one hour for both types of interview formats. In a few cases two hours were required to complete all questions. In general, interview length was proportional to the number of activities and EMF sources reported by the subject.

A complete set of interview pages is contained in Appendix B.

5

MODEL IMPLEMENTATION

5.1 Spreadsheet Structure

The interview and questionnaire obtain information about the subject, their home and occupation, the time they spend in different environments, and the time they use different sources. This information serves as input for the exposure estimation. The model is implemented as a linked collection of Excel 97® (Microsoft, Inc.) spreadsheets. The structure of the spreadsheets is shown schematically in Figure 5-1.

The model consists of spreadsheet notebooks that are linked together to facilitate data entry and computations. The FieldLevel.xls notebook contains magnetic field data characterizing environments and sources. It consists of individual spreadsheets for: 1) baseline levels in the home environment (HomeBase), 2) baseline levels in the school, travel and other environments (OtherBase), 3) field levels for all localized sources included in the model (SourceSummary), 4) field levels for the work environment by job category (JobCats), and 5) specifications for the distributions used for various exposure components (Distributions).

The SubjectData.xls notebook contains the activity, time, location, and status data for each subject collected by interviews and from subject diaries. It is comprised of separate spreadsheets for: 1) subject status information (Status), 2) data on time spent in the home environment (HomeTime), and 3) data on time spent in non-home (school, work, travel and other) environments (OtherTime). Home attributes such as locale (urban or rural) and the presence of overhead lines are contained in the Status spreadsheet. The Status spreadsheet also contains attributes associated with the other environments such as job category and type of school. The HomeTime and OtherTime spreadsheets contain information about sources used.

The TWAExposure.xls notebook contains the computation for TWA exposure based on inputs from the FieldLevel.xls and SubjectData.xls notebooks. Spreadsheets in this notebook compute exposures in the : 1) Home environment (HomeExposure), 2) School environment (SchoolExposure), 3) Work environment (WorkExposure), 4) Travel and Other environments (Travel&OtherExp.), and 5) all environments combined (TotalExposure). The notebook computes exposures for all 20 subjects in the pilot study simultaneously.

The PeakExposure.xls notebook contains analogous computations for peak exposure in all environments again based on inputs from the FieldLevel.xls and SubjectData.xls notebooks. Similarly, the HarmonicExposure.xls notebook contains the computation for exposure to harmonics in all environments. The five pages in each of these two notebooks are identical to those in the TWAExposure, but compute exposure for peak and harmonic fields, respectively.

5.2 Field Distributions

The ability to substitute probability distributions for point estimates in the Excel® model is provided by the risk analysis program @Risk® (Palisade Corporation, Newfield, NY).[1] When probability distributions are entered as inputs to the model, @Risk® generates probability distributions for model outputs through monte carlo simulation. In our case, probability distributions for EMF exposure estimates (outputs) are computed given assumed or empirical distributions for the magnetic field inputs. In this implementation of the model, the inputs for time spent in various environments, the nature of those environments, and the time spent using sources are point estimates

[1] The suggestion by Dr. William Bailey to employ probability distributions in the model using this method is gratefully acknowledged.

based on diaries and interview responses. Statistical distributions for time inputs were not employed here but could also be introduced in an exposure estimation model.

During an exposure model simulation, random selection of values from the input probability distributions is iterated a selected number (typically hundreds or thousands) of times to produce an output exposure distribution for a subject based on the information and time values provided by the interview and diary. The mean, median or other parameters of the modeled distribution can then be compared with the measured exposures.

The capability to easily repeat simulations with different input values and/or probability distributions permits examination of the effect of different exposure scenarios on model outputs. For example, the threshold for considering harmonic field exposure to be present was increased from 0.1 mG to 0.2 mG to 0.5 mG, and the resulting changes in modeled exposure noted. Another simulation entailed systematically reducing the level of fields from sources. Similarly, the impact of alternative responses to the interview can easily be evaluated.

The selection of probability distributions for the model inputs was described in detail in Section 3. There are about 100 probability distributions that serve as inputs to the computational model. Not all of these distributions are used in the computation of exposure for an individual or group, for example a subject's home cannot be classified as both rural and urban or near underground and overhead lines. Distributions for the input variables are listed in Table 5-1. Examples of cumulative distributions of selected input parameters sampled during actual model simulations are shown graphically in Figure 5-2. The construction of an output distribution from selected input distributions is shown schematically in Figure 5-3 for two source factor values.

5.3 Simulation Results

For each model simulation, @Risk® produces an estimated exposure for each iteration resulting in a distribution of estimated exposures for each subject. Estimated exposure distributions are produced for each parameter (TWA, peak and harmonics) both for each environment (Home, Work, School, Travel and Other) and for the overall period covered by the diary and interviews. The results of the simulation are reported as statistical descriptors for each output and input. These include: minimum, maximum, mean, standard deviation, and percentiles from 5 to 95 percent at 5 percent intervals. The sampled values for inputs and modeled outputs for each iteration are also reported. The model outputs can be compared with measured results.

The modeling software (@Risk®) provides two methods for examining the extent to which the estimated exposure is sensitive to the input variables of the model, both adjusted baseline and sources [Palisade Corporation, 1997]. The first available method is stepwise multivariate least-squares linear regression. This technique uses the inputs of the iterations as independent variables and the estimated exposure as the dependent variable of a multivariate linear equation. It then calculates normalized coefficients for each input variable (beta coefficients) based on the results of the iterations of the model. These normalized coefficients allow direct comparisons of the strength of the relationships between each input and estimated exposure. For example, the relative sensitivities (β coefficients from multivariate regression) of the total TWA exposure outputs shown in Figure 5-3 are listed in Table 5.2

The second available method is the computation of Spearman Rank-Order Correlation Coefficients. This technique orders the estimated exposure and each input of each iteration from lowest to highest and assigns each of them a rank. A bivariate Spearman rank-order correlation coefficient is then calculated between the ranks of each input and the ranks of the estimated exposure. This technique assesses the relationship between each input and the estimated exposure independently. The correlation coefficient calculated for the total TWA exposures shown in Figure 5-3 are listed in Table 5-2.

The results of the sensitivity analysis are, of course, dependent on the structure and assumptions in the model. For example, the output will not be sensitive to an input approximated with a point estimate. Consequently, interpretation of the results of the sensitivity analysis should be done cautiously and quantitatively.

Input variables of the model are frequently correlated, for example the presence of two-prong outlets in a home is more likely in older homes. Using secondary data culled from the literature does not permit one to parse the effects of these correlated inputs. The magnitude of the increase in field levels due to two-prong outlets may be due in part to their being present in older homes and vice versa. This is likely to produce a form of double-counting in the model and result in an inappropriate increase in the exposure estimates. This feature of the model inputs should not be confused with multicollinearity where inputs are highly correlated and the coefficients of a multiple regression are unstable. Here the inputs are either point-estimates or randomly drawn from probability distributions.

5.4 Convergence

Several initial simulations were run to determine the convergence properties of the model. Convergence is tested by comparing changes in the percentiles (every 5th percentile from 5 to 95 percent), the mean, and the standard deviation for output variables after a specified number of iterations (say, 50 iterations). The model is allowed to run until no change in any of the statistics is greater than a specified percentage. When changes in the calculations of total TWA exposure for all 20 subjects were evaluated every 50 iterations, the statistics for their estimated exposures varied less than 5% after about 500 iterations and less than 1.5% after about 1100 iterations.

Convergence for the peak exposure model occurred in about 600 iterations for the 5% change criterion and 1800 iterations for the 1.5% criterion. Convergence for harmonic exposure estimates occurred in about 500 iterations for the 5% change criterion and in about 1500 iterations for the 1.5% criterion.

Based on these results, final simulations were generally run for 1000 iterations to produce output distributions and to estimate exposures. The models were computed on a 200 MHz Pentium® personal computer with 48 MB of RAM running Microsoft Windows 95®. The processing time for 1000 iterations of the model was five to seven minutes.

Figure 5-1
Excel® Spreadsheet Structure of Exposure Computation Model

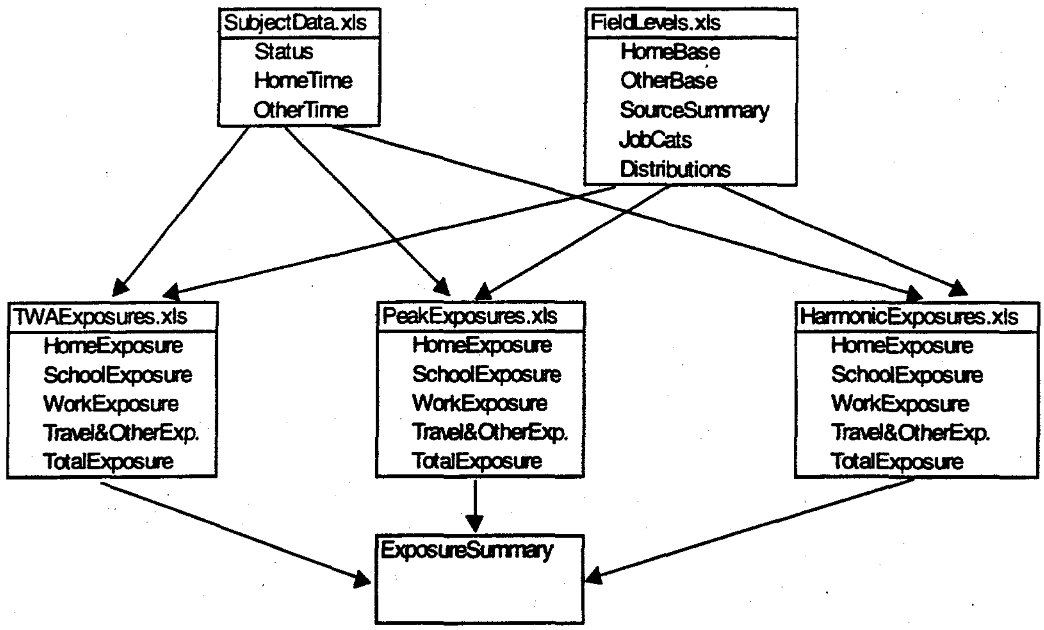
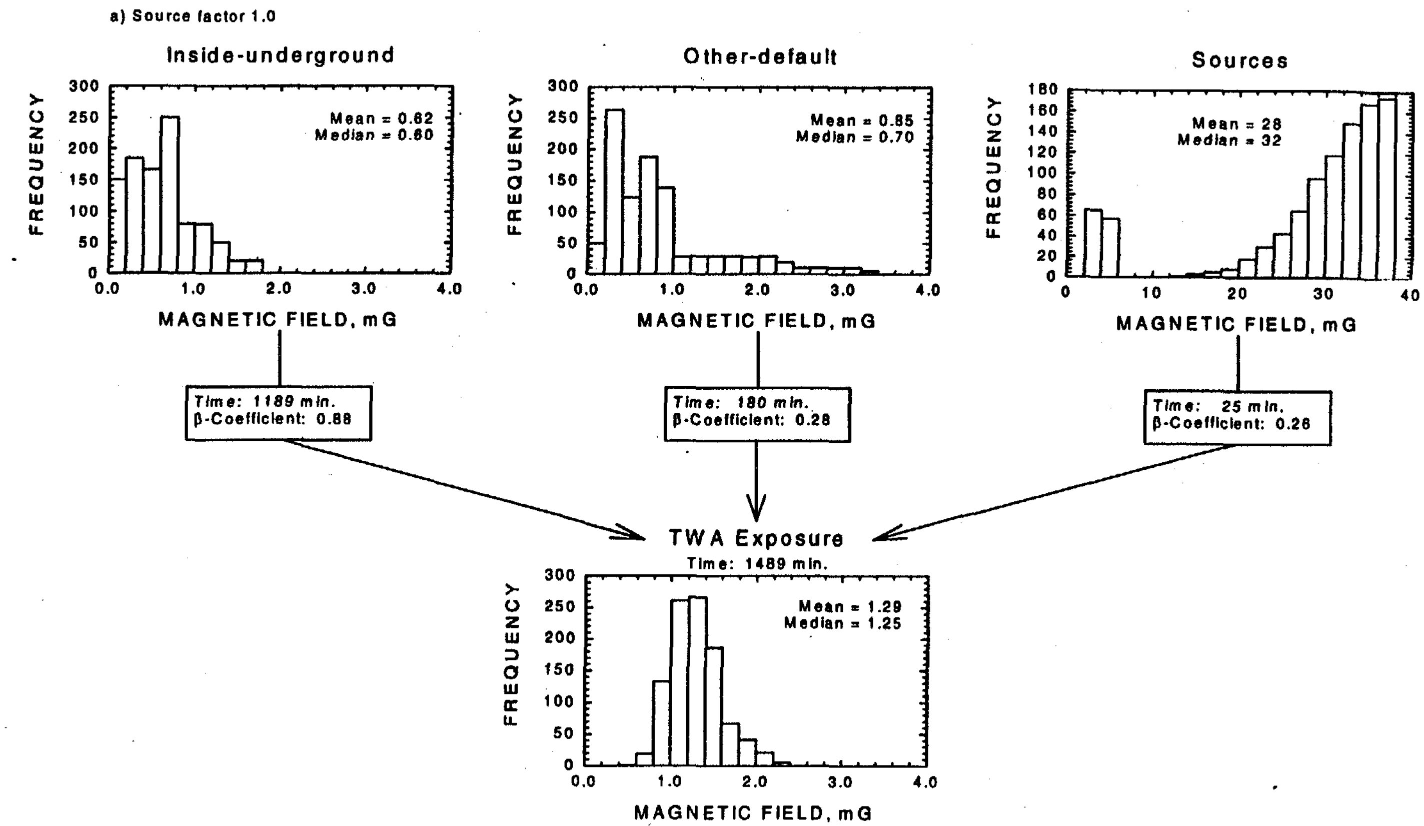


Figure 5-2
Selected Inputs and Output Distribution for Estimating Total TWA Exposure by Source Factors: a) Source factor 1.0, b) Source factor 0.05

a) Source factor 1.0



b) Source factor 0.05

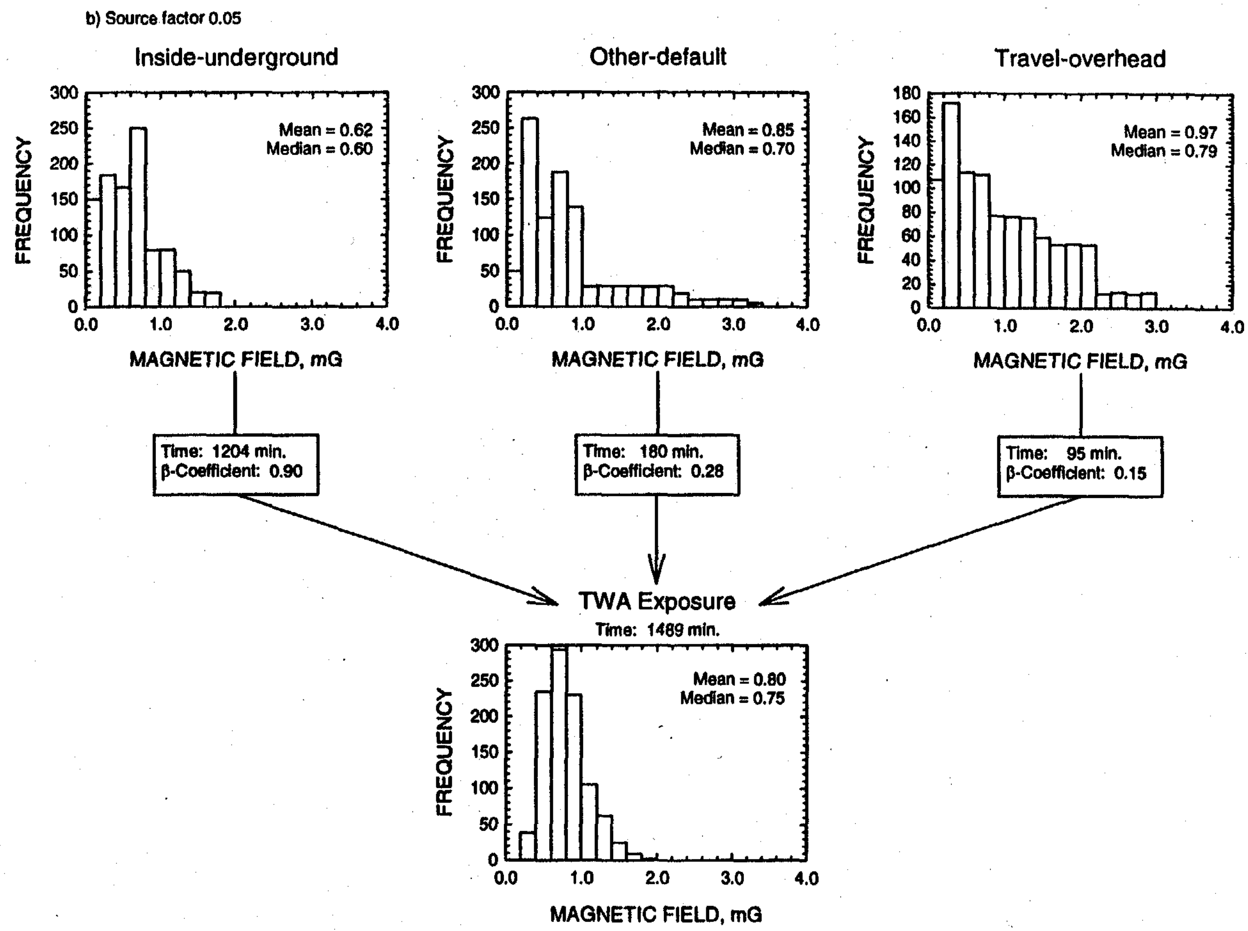


Table 5-1
EMF Exposure Model Inputs by Environment: a) Home, b) School, c) Work, d) Travel, and e) Other

TWA and Peak in mG
Harmonics in proportion to TWA

Field	Description ‡	Distribution
A) Home		
TWA	Outside-UG	CUMUL(0.05, 1.65, {0.09,0.2,0.4,0.81,1.5}, {0.05,0.25,0.5,0.75,0.95})
Peak, mG	Outside-UG	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-UG	NORMAL(0.2,0.1)
Average	Outside-rural	CUMUL(0.02, 2.6, {0.05,0.1,0.2,0.4,0.8,1.4,2.5}, {0.05,0.25,0.5,0.75,0.9,0.95,0.99})
Peak	Outside-rural	CUMUL(1, 50, {1.3,4,6,11,27}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-rural	NORMAL(0.2,0.1)
Average	Inside-UG	CUMUL(0.1, 1.8, {0.1,0.3,0.6,0.8,1.3}, {0.05,0.25,0.5,0.75,0.95})
Peak	Inside-UG	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Inside-UG	NORMAL(0.2,0.1)
Average	Inside-rural	CUMUL(0.1, 1.3,{0.1,0.3,0.5,0.7,1.3}, {0.05,0.25,0.5,0.75,0.95})
Peak	Inside-rural	CUMUL(1, 50, {1.3,4,6,11,27}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Inside-rural	NORMAL(0.2,0.1)
Average	Kitchen	TLOGNORMAL(0.2,0.1,0,1)
Peak	Kitchen	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Kitchen	NORMAL(0.2,0.1)
Average	Outside-TL	CUMUL(0.05, 12,{0.1,0.3,0.9,2.1,10.3}, {0.05,0.25,0.5,0.75,0.95})
Peak	Outside-TL	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-TL	NORMAL(0.2,0.1)
Average	Outside-OH	CUMUL(0.08, 3,{0.14,0.35,0.79,1.45,2.2}, {0.05,0.25,0.5,0.75,0.95})
Peak	Outside-OH	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-OH	NORMAL(0.2,0.1)

Field	Description ‡	Distribution
Average	Inside-TL	CUMUL(0.1, 12,{0.3,0.5,1.2,1.9,9.5}, {0.05,0.25,0.5,0.75,0.95})
Peak	Inside-TL	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Inside-TL	NORMAL(0.2,0.1)
Average	Inside-OH	CUMUL(0.2, 3.9,{0.28,0.5,0.8,1.7,3.5}, {0.05,0.25,0.5,0.75,0.95})
Peak	Inside-OH	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Inside-OH	NORMAL(0.2,0.1)
Average	Home-size	TLOGNORMAL(0.3,0.1,0,0.8)
Average	Home-age	TLOGNORMAL(0.3,0.1,0,0.8)
Average	Multi-family	TLOGNORMAL(0.3,0.2,0.1,1.3)
Average	2-prong plugs	TLOGNORMAL(0.2,0.10,0.7)
Average	Water well	TLOGNORMAL(0.2,0.1,0,0.4)
Average	Ceiling heat	TNORMAL(0.3,0.2,0,1.3)
Average	Electric blanket	TNORMAL(22,3.4,1,39)
Harmonics	Electric blanket	NORMAL(0.2,0.1)
Peak	Electric Blanket	TNORMAL(300,60,0,300)

B) School

Average	Outside-rural	CUMUL(0.02, 2.6, {0.05,0.1,0.2,0.4,0.8,1.4,2.5}, {0.05,0.25,0.5,0.75,0.9,0.95,0.99})
Peak	Outside-rural	CUMUL(1, 50, {1.3,4,6,11,27}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-rural	NORMAL(0.35,0.1)
Average	Outside-UG	CUMUL(0.05, 1.65, {0.09,0.2,0.4,0.81,1.5}, {0.05,0.25,0.5,0.75,0.95})
Peak	Outside-UG	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-UG	NORMAL(0.35,0.1)
Average	Outside-OH	CUMUL(0.08, 3,{0.14,0.35,0.79,1.45,2.2}, {0.05,0.25,0.5,0.75,0.95})
Peak	Outside-OH	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Outside-OH	NORMAL(0.35,0.1)
Average	Inside	CUMUL(0, 6.6, {0.09,0.16,0.3,0.41,0.69,1.1,1.92,3.32}, {0.01,0.05,0.25,0.5,0.75,0.9,0.95,0.99})
Harmonics	Inside	NORMAL(0.35,0.1)

	Field	Description ‡	Distribution
	Peak	Inside	NORMAL(100,5)
	Average	Outside-TL	CUMUL(0.05, 12,{0.1,0.3,0.9,2.1,10.3}, {0.05,0.25,0.5,0.75,0.95})
	Peak	Outside-TL	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Outside-TL	NORMAL(0.35,0.1)
	Harmonics	Remote	NORMAL(0.35,0.1)
C)	Work		
	TWA	Job Code ##	LOGNORMAL(AM##, SD##)†
	Peak	At work	CUMUL(5,1700, {20,40,50,100,120,210,400,1000}, {0.05,0.25,0.5,0.75,0.9,0.95,0.99,0.995})
	Harmonics	At work	NORMAL(0.1,0.05)
D)	Travel		
	TWA	Outside-rural	CUMUL(0.02, 2.6, {0.05,0.1,0.2,0.4,0.8,1.4,2.5}, {0.05,0.25,0.5,0.75,0.9,0.95,0.99})
	Peak	Outside-rural	CUMUL(1, 50, {1.3,4,6,11,27}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Outside-rural	NORMAL(0.2,0.1)
	TWA	Outside-UG	CUMUL(0.05, 1.65, {0.09,0.2,0.4,0.81,1.5}, {0.05,0.25,0.5,0.75,0.95})
	Peak	Outside-UG	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Outside-UG	NORMAL(0.2,0.1)
	TWA	Outside-OH	CUMUL(0.08, 3,{0.14,0.35,0.79,1.45,2.2}, {0.05,0.25,0.5,0.75,0.95})
	Peak	Outside-OH	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Outside-OH	NORMAL(0.2,0.1)
	TWA	Outside-TL	CUMUL(0.05, 12,{0.1,0.3,0.9,2.1,10.3}, {0.05,0.25,0.5,0.75,0.95})
	Peak	Outside-TL	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Outside-TL	NORMAL(0.2,0.1)
E)	Other		
	TWA	Default, other	CUMUL(0.2, 3.3,{0.2,0.3,0.7,0.9,2.3}, {0.05,0.25,0.5,0.75,0.95})
	Peak	Default, other	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
	Harmonics	Default, other	NORMAL(0.2,0.1)

Field	Description ‡	Distribution
TWA	Grocery store	TLOGNORMAL(2.2,0.7,0.1,4.3)
Harmonics	Grocery store	NORMAL(0.2,0.1)
Peak	Grocery Store	NORMAL(37,2)
TWA	Transmission line	CUMUL(0.05, 12,{0.1,0.3,0.9,2.1,10.3}, {0.05,0.25,0.5,0.75,0.95})
Peak	Transmission line	CUMUL(1,70, {1.4,3,8,17,51}, {0.05,0.25,0.5,0.75,0.95})
Harmonics	Transmission line	NORMAL(0.2,0.1)
Harmonics	Remote	NORMAL(0.2,0.1)

‡ UG = underground, OH = overhead, TL = transmission line
† AM## = arithmetic mean for Job Code ##, SD## = standard deviation for Job Code ##
* Distributions are given in terms of @Risk functions. See Table 3-3

Table 5-2
Sensitivity Analyses for Estimated Total TWA Exposure for Subject 1 (Figure 5-2)

a) Source factor = 1.0

	Factor	Beta Coefficient	Rank-Order Correlation	Time	Median, mG
Output	TWA	—	—	1489	1.25
Inputs	Inside-UG	.88	.85	1189	.60
	Other-default	.28	.29	180	.70
	Source	.26	.23	25	32
	Travel OH	.15	.14	7.5	.79
	Home age	.14	.15	1189	.28
	Two-prong	.10	.18	1189	.18

b) Source Factor = 0.05

		Beta Coefficient	Rank-Order Correlation	Time	Median, mG
Output	TWA	—	—	1489	0.75
Inputs	Inside-UG	.90	.89	1204	3.60
	Other-default	.28	.30	180	.70
	Travel OH	.15	.15	95	.79
	Home age	.15	.17	1204	.28
	Two-prong	.10	.21	1204	.18
	Source level	.01	+.05	10	4

6

PILOT STUDY

6.1 Objectives

The objectives of the pilot study were:

1) to demonstrate and test two methods for obtaining activity and exposure source information: a retrospective interview only and a concurrent subject-administered diary coupled with a retrospective interview; and
2) to collect input data for a demonstration of the exposure model.

6.2 Study Design

6.2.1 Sampling

The pilot employed a convenience sample and the subjects were not representative of the inhabitants of the area where the pilot was conducted. For example, 85% of the pilot subjects were employed whereas 65% of the population in the area were employed (1990 Census: persons 16 years and over in the Oakland CA Primary Metropolitan Statistical Area). Comparisons between the estimated and measured exposures of the pilot subjects should be considered only suggestive of the model's predictive power, greater or lesser accuracy is possible for a more representative sample.

6.2.2 Interview Method

The pilot study employed two approaches for obtaining activity and exposure source information. All the participants wore a PE meter for 24-hours. Half were interviewed retrospectively to estimate the time spent in various environments as well as collect information regarding their activities and use of sources during the time they wore the PE meter. The other half of the participants kept a concurrent diary of their activities and were interviewed following their wearing of the meter to obtain more detailed information about their activities.

6.2.3 Magnetic Field Measurements

The exposure model predicts exposure for three magnetic field parameters: time-weighted average PE, peak field, and fraction of time with harmonic fields present. All three of these PE parameters were measured with EMDEX II magnetic field meters worn by the pilot-study participants for approximately 24 hours. Using custom software, the meters were programmed to sample at 5-second intervals and record the magnitude of the broadband (40 - 800 Hz) and harmonic (100 - 800 Hz) magnetic field. The meters displayed the time of day which participants used to complete the concurrent diary.

New batteries were installed prior to each deployment of the meter. The EMDEX meters were initialized prior to deploying the meter. The subjects wore the meter in a pouch secured at the waist with a belt. Subject Instructions were provided to ensure study protocols were followed. After the 24-hour measurement period, the meter was retrieved by the interviewer. It was downloaded by the interviewer in his office after the visit to the interview location.

6.2.4 Data Collection

After confirming the availability of a participant for measurements, the interviewer scheduled a visit to obtain informed consent, instruct the participant in measurement protocols, and begin data collection. Each participant was asked to wear the meter for a 24-hour period. When running the custom software, the meter can accumulate data for approximately 28 hours, at which time the meter would automatically go into a powersaving mode of operation with the data preserved for several days. Thus, the interviewer had some flexibility in scheduling a time to conduct the closing interview and retrieve the meter. However, to ensure accurate recall of the measurement period by the participant, it was preferable to conduct the interview as soon as possible.

The interviewer followed a checklist in conducting both the initial visit and closing interview. The data collection forms used to record activity, source, and subject data are listed in Table 6.2. A complete set of data collection forms is included in Appendix B. Each participant was given Subject Information and the Meter Log Location. This latter form provided a record of when, where, and why the PE meter was not worn and when the meter was put back on. It did not request activity information directly but entries could serve as cues to the activities of the subject.

Activities and sources used during the measurement period were recorded in one of two diary formats depending on which protocol for recording participant activities was to be used. When only a retrospective interview was used, the Retrospective Diary provided a means for the interviewer to obtain and record a sequential list of activities for the subject during the measurement day. The format of the interview was intended to facilitate accurate recall of activities by the subject. Each activity description included: the time the activity began; what the subject was doing; where the subject was; what, if any, electrical appliances or equipment were used; and what time the activity ended.

Similar information was included on the self-administered concurrent diary forms completed by the subjects during the measurement period. In addition, when the concurrent diary was used, the interviewer reviewed the diary entries during the closing interview and collected additional information about activities and sources with supplemental forms (Diary Supplement: Activities, Diary Supplement: Sources).

Both approaches to recording activities employed the Post-Diary Interview and Interviewer Observations Forms, which recorded information about the subject, the environments occupied by the subject and the subject's residence. The interviewer also employed a supplemental list of sources by environment (Source Bookmarks) and a form containing questions about additional sources not recorded in the diary (Follow-up Sources) to ensure that all sources had been accounted for.

6.2.5 Subject Issues

The interviewer initially contacted each subject by telephone to determine their willingness to participate in the pilot study. The interviewer then scheduled a visit. During the visit the potential participant received a description of the study and was asked to complete a consent form (see Appendix B). The consent form had been approved by the Oak Ridge National Laboratory Human Studies Committee, the project's manager, and by the University of California, Berkeley Human Studies Committee, the interviewer's organization. If the subject agreed to participate and executed the consent form, the interviewer then instructed the subject in the use of the PE meter and completion of the data collection forms (Meter Location Log and, if applicable, Concurrent Diary).

The interviewer returned after the measurement period and completed the closing interview with the participant. The meter was retrieved and the data downloaded to a personal computer. The results of the PE measurements were plotted and returned to the participant with a $25 check in appreciation of their participation. The interviewer also contacted the participants to thank them and answer any final questions they had about the measurement period.

6.2.6 Data Management

Data files and interview forms and diaries from the EMDEX II meters were sent to project headquarters where they were entered into databases. The measurement files were converted to binary time series files which could be manipulated and analyzed using custom software. Information from the interview forms and diaries was entered into a spreadsheet which could easily be accessed for use in the model or for linking form data to measurements.

Magnetic field data from each subject were visually examined in field-versus-time plots to confirm periods when the instrument may have been placed near a source, for example near a bedroom clock during sleep. The interviewer had also identified these periods in an initial review of the data. Such periods are characterized by a period of constant field elevated above the normal levels when the meter was worn. Magnetic field measurements for such periods were not considered representative of actual PE and were excluded from analyses. This occurred for three subjects. Annotated field-versus-time plots for broadband and harmonic fields for all subjects are shown in Appendix C.

The magnetic field data for each subject was linked with the interview forms and diaries to produce summary files for each subject. For comparison with the model, statistical summary measures were produced for two temporal aggregations of measurements: for the entire session (about 24 hours) and for the aggregated time spent in each environment (home, school, work, travel, other) during a session. Each session or environment record in the summary data file contained summary measures for the magnetic field measurements, plus subject, environment, activity and time information relevant to that record. A list of the fields in each record of the summary data files is contained in Appendix C.

6.3 Pilot Study Observations

Observations from the pilot studies provide some insight into the effectiveness and efficiency of interviewer-administrated and self-administered diaries in obtaining activity and source information related to EMF exposures. For example, the number of activities reported by participants ranged from 7 to 28 with an average of about 18 activities. The number of EMF sources reported ranged from 2 to 15, averaging 6.5 sources per subject. The numbers of activities and sources by type of data collection are shown in Table 6-3. In general, more activities and sources were reported for the retrospective interview than for the combination of a concurrent diary and diary supplements. The sample is quite small (20) and this result could be due to chance.

The retrospective interviews were generally easier to administer when the participant had not maintained a concurrent diary. There were more problems and correcting of previous answers for concurrent diary users. Some respondents using the concurrent diary had not been diligent in filling it out. In several cases, the interviewer had to review the entire concurrent diary, making corrections in the types of activities, adding activities that had not been recorded, and adjusting the start and end times. These observations suggest that, in this case, the retrospective interview may have been a more efficient and complete method for capturing information. However, before generalizing this observation, additional research is needed because of the small sample size and the very limited testing of protocols.

Table 6-1
Characteristics of Pilot Study Participants

Characteristic		Activity Diary Protocol: Retrospective Interview	Activity Diary Protocol: Concurrent Diary and Diary Supplements
Gender:	Male	6	3
	Female	4	7
Status:	Working	8	9
	Non-Working	2	1
Spent Time At:	Home	10	10
	Work	6	9
	School	1	0
	Travel	9	10
	Other	8	10
Overhead Lines (Home)		8	10
Area:	Urban	2	0
	Suburban	7	10
	Rural	1	0

Table 6-2
Data Collection Forms Used in Pilot Study

Type of Form	Retrospective Diary	Concurrent Diary and Supplements
	X	Subject Instructions X
Meter Location Log	Subject	Subject
Concurrent Diary		Subject
Diary Supplement: Activities		Interviewer
Diary Supplement: Sources		Interviewer
Retrospective Diary	Interviewer	
Post-Diary Interview	Interviewer	Interviewer
Source Bookmarks	Interviewer	Interviewer
Follow-up: Sources	Interviewer	Interviewer
Interviewer Observations	Interviewer	Interviewer

Key:

Subject = Form is completed by the subject.
Interviewer = Form is completed by the interviewer, usually during the subject interview.
X = Form is only informational.

Table 6-3
Numbers of Activities and Sources by Interview Format

Interview Format	Retrospective Diary		Concurrent Diary		All subjects	
	Range	Mean	Range	Mean	Range	Mean
Activities	10 - 28	19.8	7 - 24	16.8	7 – 28	18.3
Sources	5 - 15	7.3	2 - 10	5.6	2 – 15	6.5

7

RESULTS OF PILOT STUDY

7.1 Measured Exposures

Twenty subjects completed PE measurements over approximately 24-hour periods. Measured exposures for the overall measurement period and for each environment are presented in Table 7-1 for TWA, peak, and harmonic exposures.

All subjects (20) spent time in the Home environment and most subjects spent time in the Work environment (13), Travel environment (19) and Other environment (16). Only two subjects spent time in the School environment. Measurements during a period of time at home were excluded from analysis for three subjects. During the excluded periods, the meter had been placed near an electric clock during sleep, and the measurements were no longer considered representative of TWA exposure.

The subjects' time was predominantly spent at the home, with an average of about 966 minutes (65 percent of time) during the measurement period for all subjects. Mean time in other environments, for subjects who spent time in the environment, were: 479 minutes (32 percent of time) in the Work environment; 126 minutes (9 percent of time) in the Travel environment; and 96 minutes (6 percent of time) in the Other environment. As shown in Table 7-2, the average percent of time spent at home by all subjects is comparable with the percent of time in environments reported for 381 San Francisco Bay Area adults [Wiley et al., 1991b].

The average Total TWA for the 20 subjects in the pilot study was 0.84 mG with a range of 0.26 to 2.00 mG, as shown in Table 7-1a. The highest TWA exposures tended to occur in the Other environment (average 1.69 mG) and the lowest in the Home environment (average 0.67 mG). The Total TWA fields reported in Table 7-1a are somewhat lower than those estimated for the general public in the 1000-Person Study. In that study, the estimated TWA for the general population of the United States was: mean of 1.26 mG, median of 0.88 mG, and 5th and 95th percentiles of 0.26 and 3.26 mG, respectively.

The average peak field for all subjects was 40 mG with a range of 8 to 140 mG. The highest peak fields occurred in the Home and Travel environments with Work and Other environments slightly lower. As with the TWA fields, the peak fields for total exposure are low compared with maximum values reported in the 1000-Person Study [Zaffanella and Kalton, 1998]. For example, the median peak field for the 20 subjects during the pilot study was 26 mG, compared to a median peak of 50 mG in the 1000-Person Study. The maximum peak field for pilot study subjects was 140 mG, which corresponded to the 87th percentile of peak fields observed by the 1000-Person Study. In that study, peak fields above 1 G were observed.

The average level of harmonic fields for subjects during the pilot study was 0.19 mG. Average fractions of time above 0.1, 0.2 and 0.5 mG were 0.66, 0.29 and 0.05, respectively. Mean measured harmonic fields for the pilot study subjects were somewhat higher in the Travel and Other environments, corresponding to the higher TWA fields encountered in these environments

The differences between measurements in the pilot study and those in the more representative 1000-Person Study are due in part to the small size and lack of diversity in the pilot study sample. Another factor is the difference in measurement sampling intervals between the pilot study (5 second) and the 1000-Person Study (0.5 second). Smaller measurement intervals are more likely to capture brief peak fields.

Percentiles were calculated, at 5% increments, for the measurements of each subject (i.e., 5th percentile, 10th percentile, etc.). These percentiles were examined with a Lilliefors Test of Normality (SPSS Version 7.5). The distributions of measurements of ten of the

20 subjects were found to not be normal. The field levels at each percentile were transformed by a natural logarithm function. These transformed values were examined with a Lilliefors test and the distributions of measurements of only 7 of the 20 subjects were found to not be normal. The distributions appear to be roughly lognormal, a finding consistent with many previous studies of magnetic field exposure.

7.2 Modeled Exposures

The time, environment and source use information from the subject interviews and diaries were entered into the exposure model to produce estimated exposures of TWA, peak, and harmonic field for each subject. Summary statistics for the estimated distributions for each exposure parameter by subject and, where appropriate, by source level are contained in Appendix E with selected summary statistics presented in Table 7-3.

The estimated exposures are compared with measured exposures by subject in Figures 7-1 to 7-7. The median of the estimated exposures is used for comparison with measured exposure. This statistical descriptor best characterizes modeled exposure for the "typical" day: that is, half the estimated exposures are above the median and half are below it.

7.2.1 TWA

The medians of estimated total TWA exposure for a source factor of 0.05 ranged from 0.51 to 1.76 mG with a mean of 1.15 mG. The measured TWA values ranged from 0.11 to 2.0 mG with a mean for all subjects of 0.84. The 5^{th}, 50^{th} (median) and 95^{th} percentiles of the distributions of the total TWA exposure estimates are presented in Figure 7-1 by TWA source factor. Also presented in Figure 7-1 is the measured TWA for each subject. The subjects have been ordered by measured TWA exposure for presentation purposes. The median estimated TWA levels are considerably higher than the corresponding measured levels for the subjects. The ratios of median estimated to measured mean exposures have an average of 2.2 and standard deviation of 1.6 for a source factor of 1 and average 1.7 with 1.0 standard deviation for a source factor of 0.05. Even when contributions to exposure from sources are minimized (TWA source factor = 0.01) the median estimated levels are higher than measured values in all but a few cases. The model produces a probability distribution for the estimated TWA of each subject. The measured mean of 16 of the 20 subjects (80%) was within the 5th to 95th percentile interval of estimated TWA.

A scatter plot of the median estimated total TWA exposure with a source factor of 0.05 versus the ,mean measured total TWA is shown in Figure 7-2. The linear correlation coefficient between estimated and measured TWA exposures for the 20 subjects is 0.24 when using a source factor of 1 in the model and 0.63 for a source factor of 0.05.

Estimated TWA exposures in the Home environment (Figure 7-3) follow the trends seen for total TWA exposure. Most mean measured values (17 of 20) are below the median estimated exposures even when the contribution of sources to exposure is minimized. Estimated 95th percentiles of 9 mG, two subjects in Figure 7-3, are the model's response to a transmission line near their residence. The mean measured exposure of 13 of the 20 subjects was within the 5th and 95th (65%) percentile interval of the estimated TWA distribution for the Home environment.

Estimated Work mean TWA exposures for 13 subjects with time in the Work environment are compared with measured TWA exposure in Figure 7-4. Measured exposures tend to be lower than the TWA exposures estimated from the job exposure matrix. Most measured exposures (8 of 13, 61%) fall between the 5th and 95th percentile of estimated exposure for the Job category.

Estimated Travel TWA exposures are compared with mean measured Travel TWA exposure in Figure 7-5 for the 19 subjects with time spent traveling. The mean measured exposures are equal to or exceed the median estimated TWA for the Travel environment. The identical estimated exposure for many subjects reflects the model's response to the subjects traveling in the same baseline field: by automobile in areas with overhead distribution lines.

Mean measured and estimated TWA exposures in the Other environment are shown in Figure 7-6 for 16 subjects. Measured exposures generally exceeded median estimated exposures.

The sensitivity of each subject model's estimated total TWA exposure to its inputs was examined for various source factor levels. Both the multivariate linear regression and rank-order correlation methods available in @Risk® produced similar results. The results of the sensitivity analysis are shown in Table 7-4 subject for TWA source factors of 1.0 and 0.05. (The sensitivity analysis results using a source factor of 0.01 were equivalent to those for 0.05.) Since the results are primarily of qualitative interest, only the beta (β) coefficients from the multivariate linear regression method are presented. The β coefficients for most variables included in the subject's model are shown, even though coefficient values below 0.1 have little impact.

The Total TWA estimated exposure was consistently most sensitive (i. e., highest β coefficient) to the inside baseline fields of the Home environment and to the Work environment field, if the subject reported time at work. The inside baseline field had the highest β coefficient in 15 of the 20 cases and the Work environment field had the highest in beta the remaining five cases. These results are to be expected since subjects spend the overwhelming majority of their time inside at home. Time spent in the Work environment can also be considerable. In addition, the estimated TWA fields in the Work environment are generally higher than in the Home environment. The β coefficient for the dominant input, whether inside at home or at work, ranged from 0.7 to 1.0 in simulations with a source factor of 0.05. Most values were above 0.9.

When the source factor was assumed to be 1 and the effect of sources was maximized, the β coefficient for sources was frequently high enough to place this input among the two or three most influential input variables for a subject. However, when the source factor was reduced to 0.05, Total TWA exposures were not sensitive to source-related inputs to the model.

Other input variables that exhibited relatively high β coefficients for a particular subject were the baseline fields associated with time in the Travel and Other environments. Not surprisingly, total TWA exposure did not exhibit sensitivity to the relatively modest fields associated with adjustments to baseline levels.

7.2.2 Peak

Estimated and measured peak exposures are shown in Figure 7-7 for several peak source factors. The estimated peak exposures for source factors of 1 and 0.1 are well above measured peak exposures, some differ by as much as 600 orders of magnitude (Figure 7-7). Peak exposures estimated with the lower source factor of 0.01 vary from 54 to 461 mG with a mean of 136 mG. These values are closer to the measured peak values, which range from 8 to 140 mG with a mean of 40 mG.

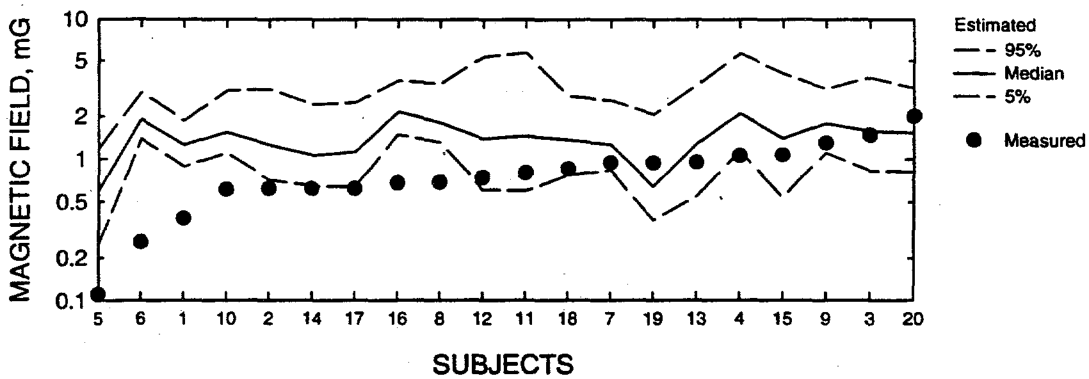
7.2.3 Harmonics

The median estimated and measured fractions of time that harmonic fields exceed 0.1 and 0.2 mG during the measurement period are plotted in Figure 7-8 for a source factor of 0.05. As expected, both the estimated and measured fraction of harmonics decrease as the harmonic threshold increases. The average estimated fraction for all subjects goes from 0.61 to 0.20 as the threshold goes from 0.1 to 0.2 mG. The average measured fraction for subjects goes from 0.66 to 0.29 for the same change in threshold.

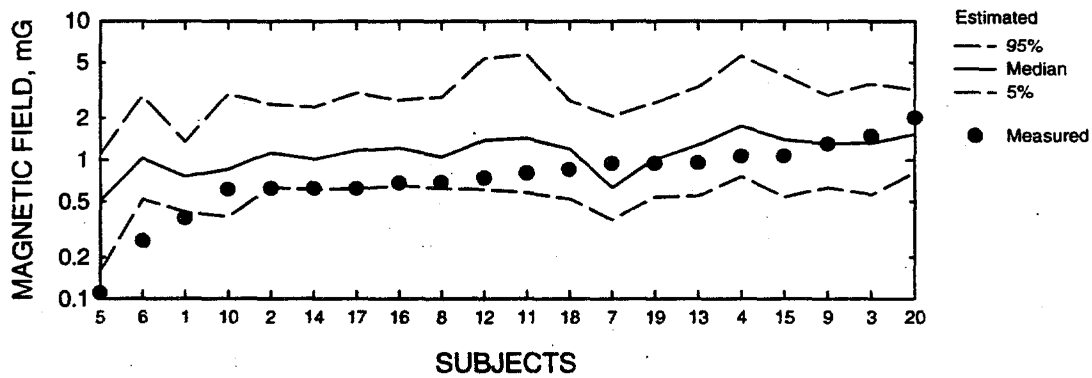
For the lower threshold (0.1 mG), the fraction of harmonic tends to be over-estimated by the median estimate for these subjects with a small fraction of harmonics. Conversely, the fraction tends to be under-estimated for those with higher fractions of harmonics. This same pattern is observed for the higher threshold (0.2 mG), where the estimated fraction is substantially below the measured fraction for those with a high measured fraction.

Figure 7-1
Estimated and Measured Total TWA Exposures by Subject by TWA Source Factor

a) Source factor 1



b) Source factor 0.05



c) Source factor 0.01

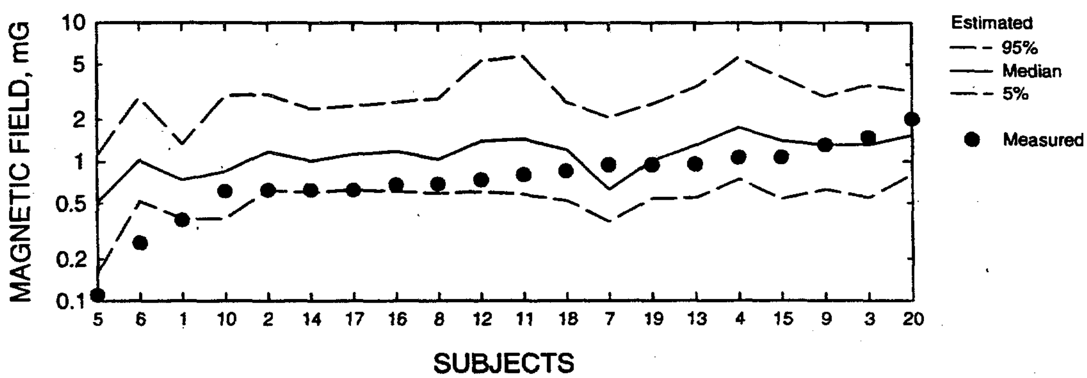


Figure 7-2
Estimated Versus Measured Total TWA Exposures for TWA Source Factor 0.05

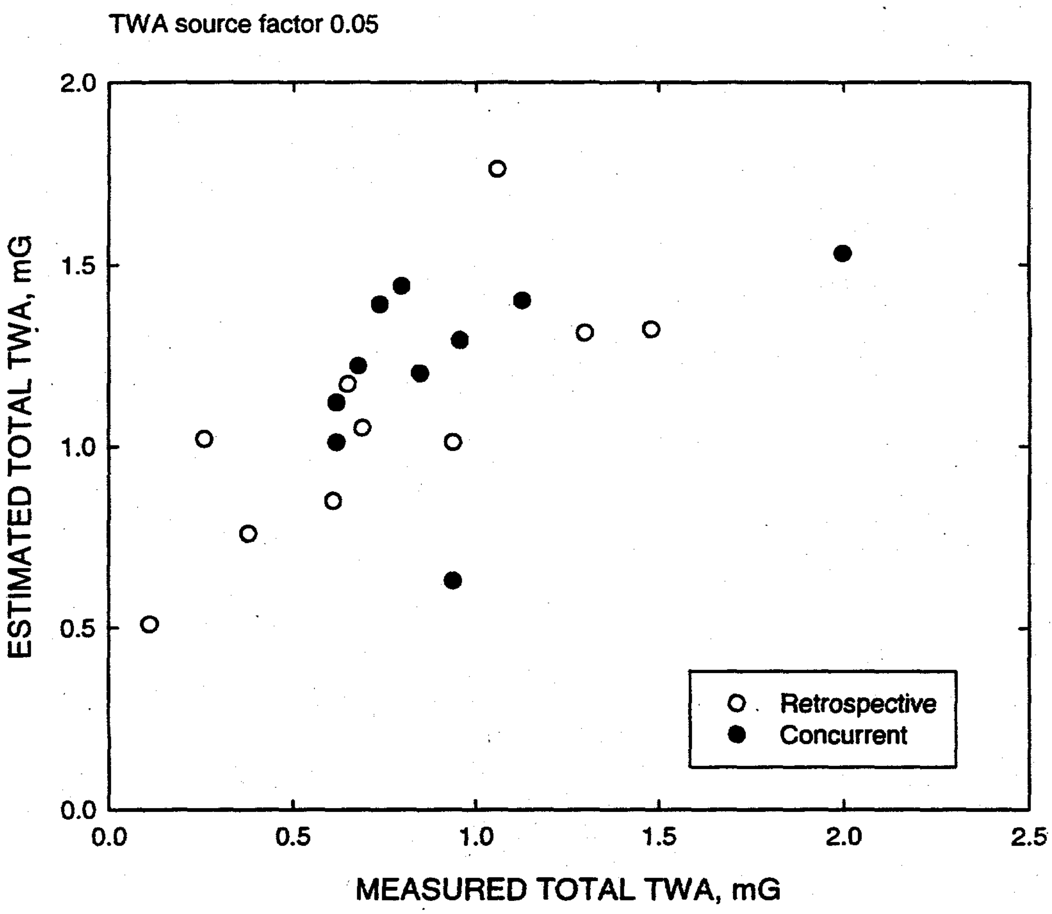
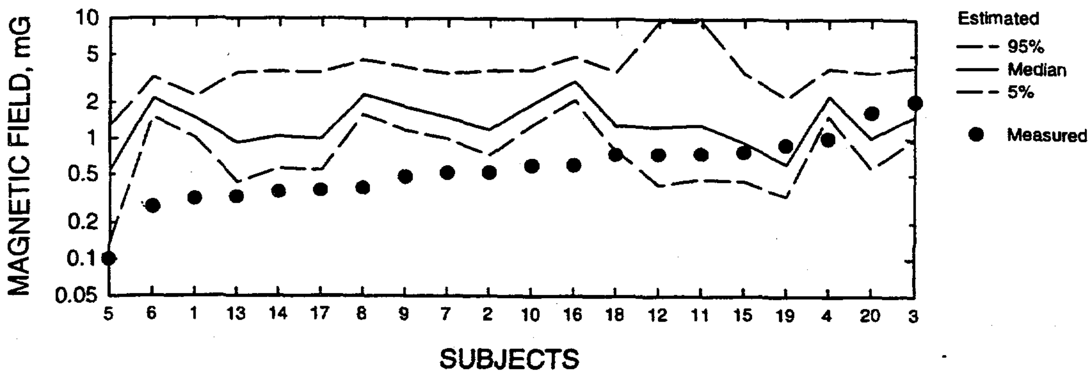
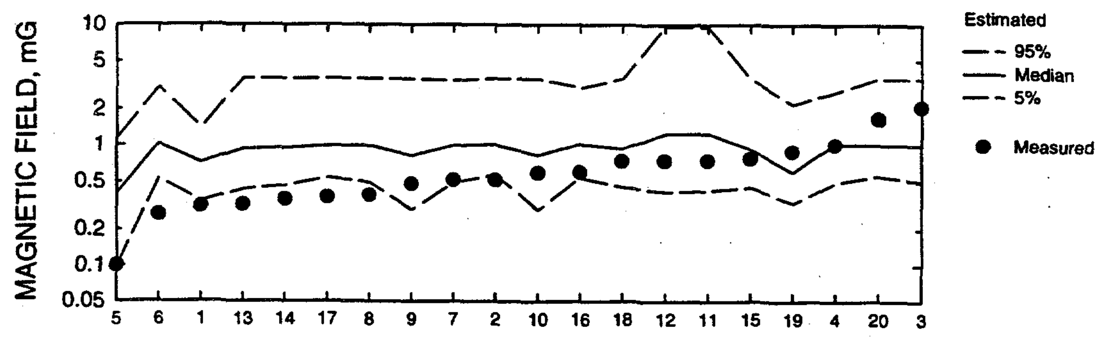


Figure 7-3
Estimated and Measured TWA Exposures by Subject by TWA Source Factor for Home Environment

a) Source factor 1



c) Source factor 0.01



b) Source factor 0.05

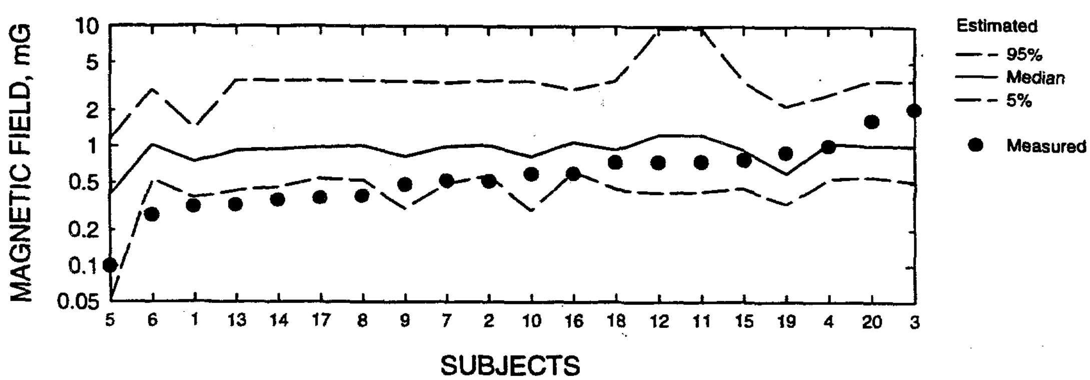


Figure 7-4
Estimated and Measured TWA Exposures by Subject for Work Environment

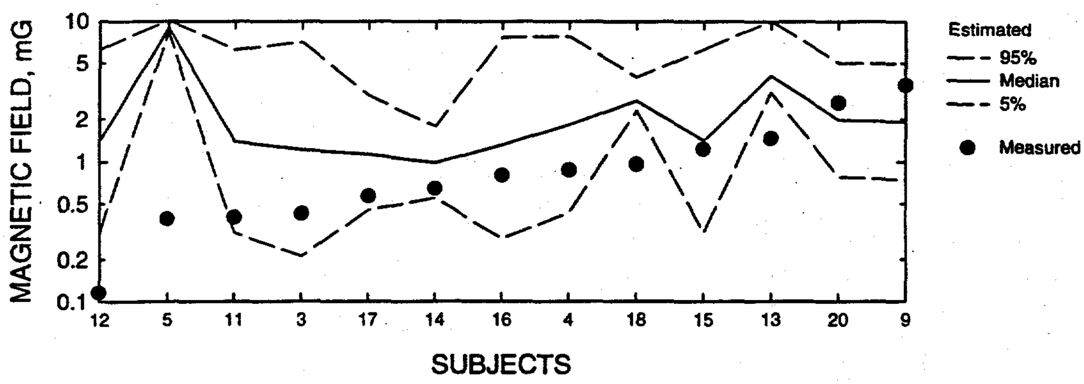


Figure 7-5
Estimated and Measured TWA Exposures by Subject for Travel Environment

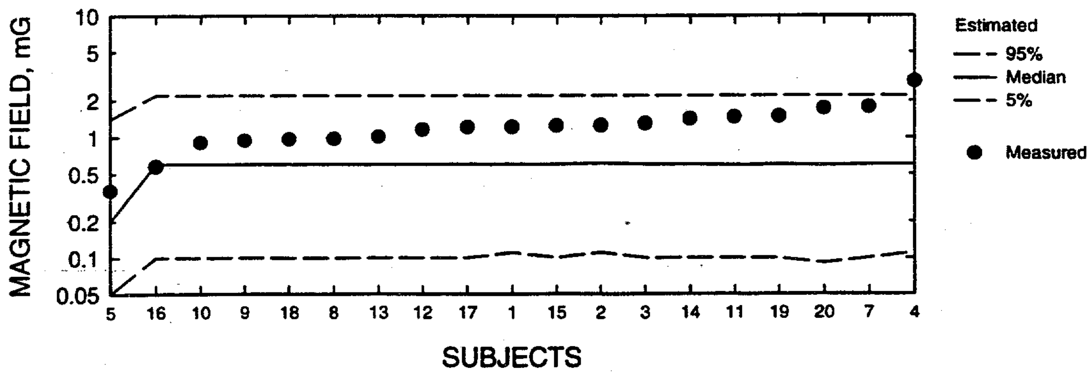


Figure 7-6
Estimated and Measured TWA Exposures by Subject for Other Environment

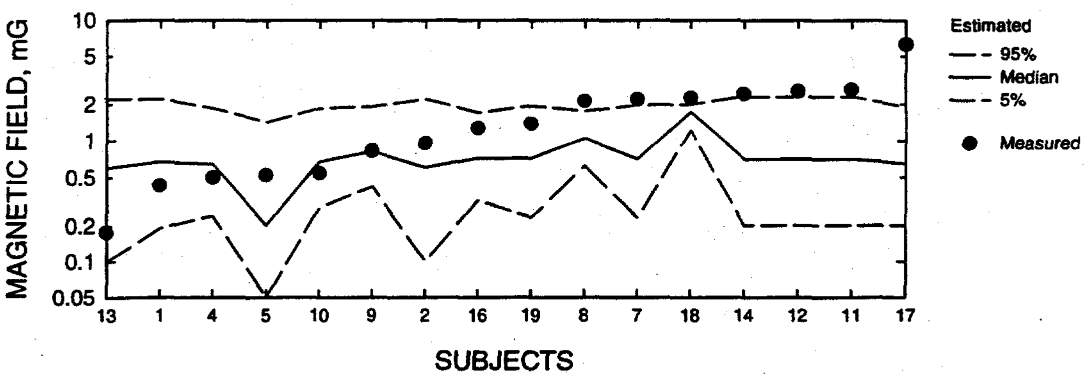


Figure 7-7
Estimated and Measured Peak Exposures by Subject by Peak Source Factor for All Environments

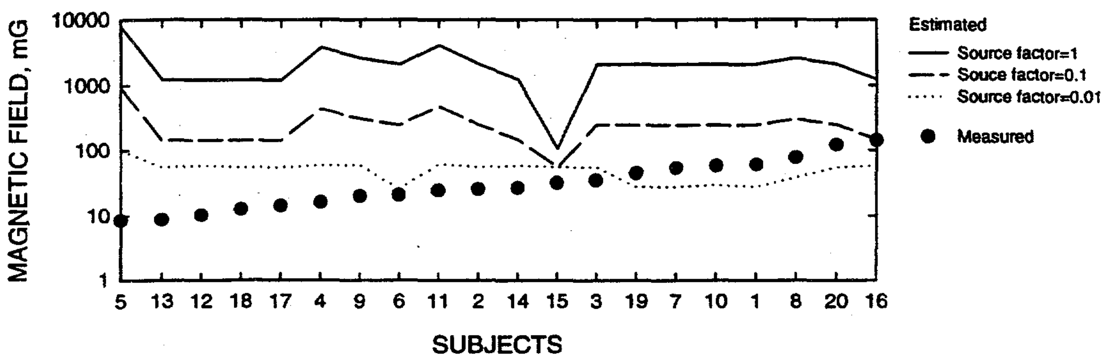


Figure 7-8
Estimated and Measured Harmonic Exposures by Subject by Harmonic Threshold Level for All Environments for Source Factor 0.05

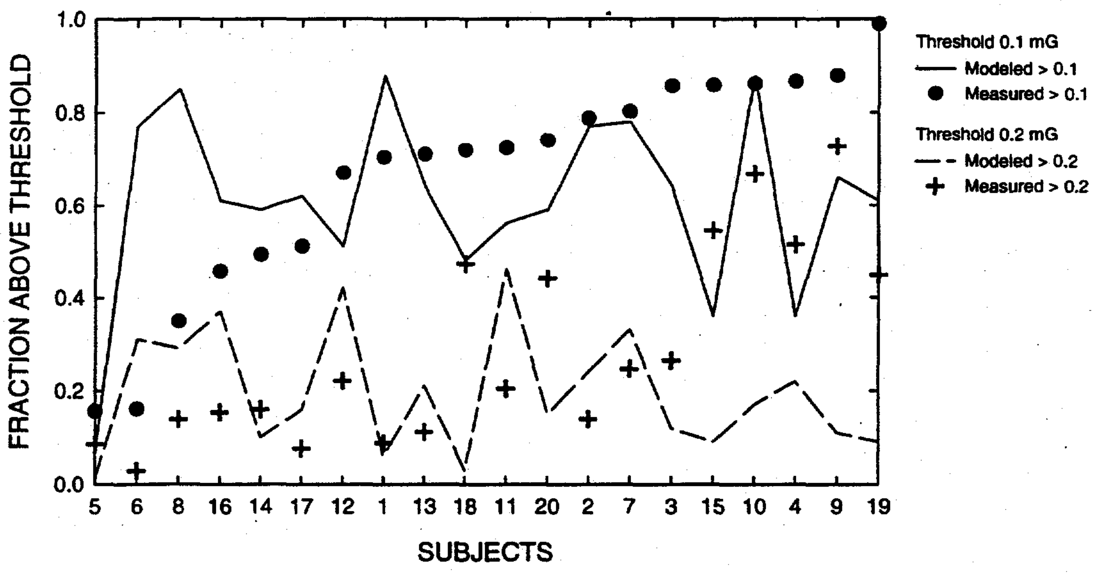
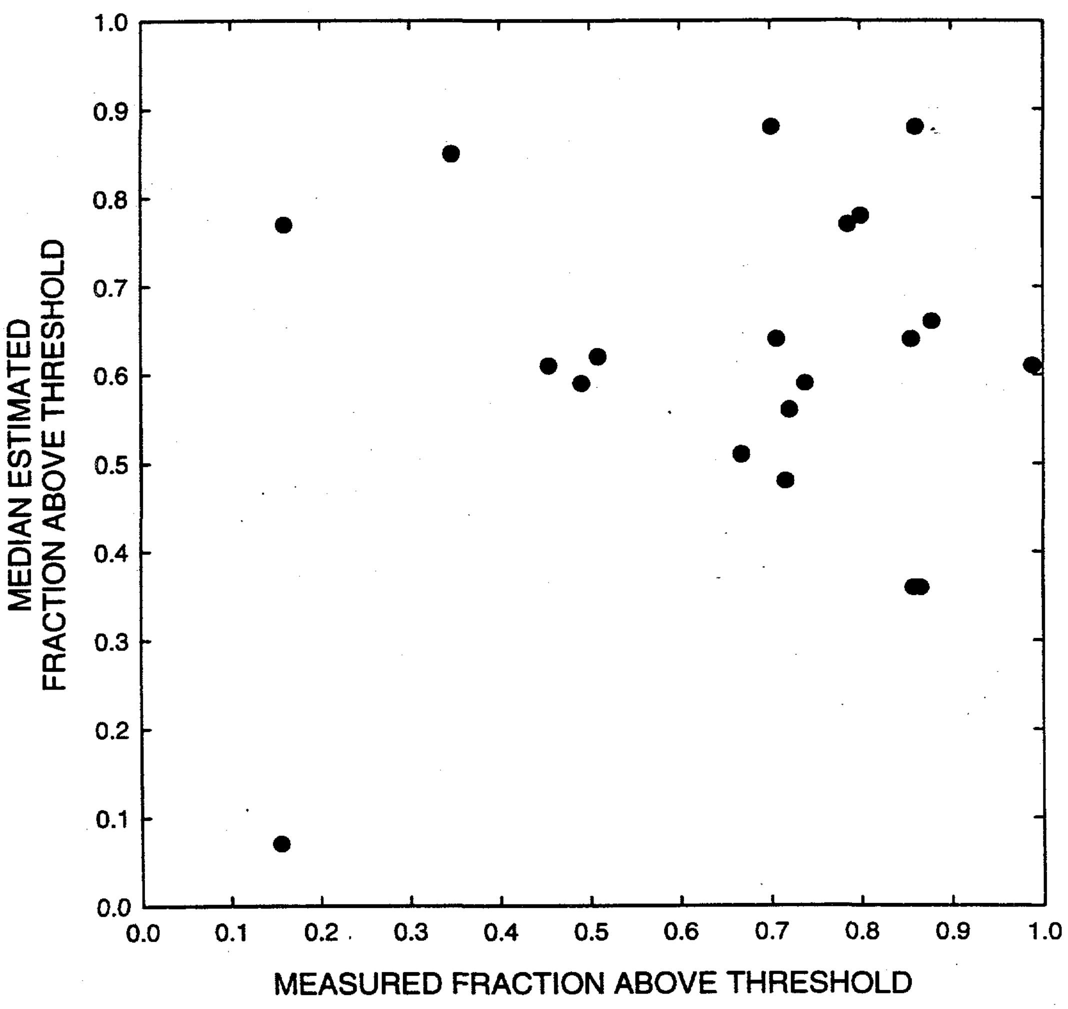


Figure 7-9
Estimated Versus Measured Fraction of Harmonics above Threshold: a) Threshold 0.1 mG; b) Threshold 0.2 mG

a) Threshold 0.1 mG



b) Threshold 0.2 mG

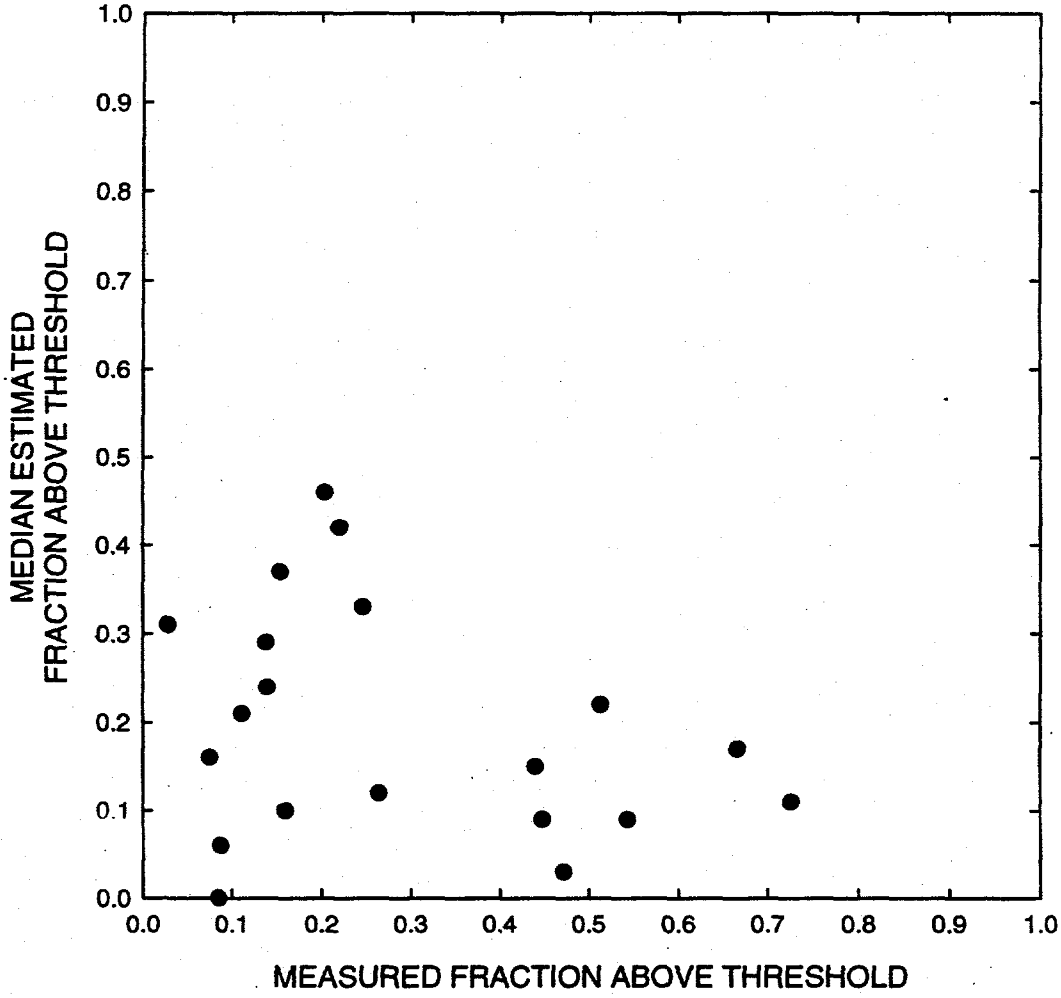


Table 7-1
Pilot Study PE Measurements of TWA, Peak, and Harmonic Fields Overall and by Environment by Subject: a) Total; b) Home; c) Work; d) School; e) Travel; f) Other

a) Total

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
1	1509	0.38	1.50	59.70	0.10	0.70	0.09	0.01
2	1527*	0.65	1.13	25.10	0.15	0.79	0.14	0.02
3	1423	1.48	1.84	34.50	0.46	0.86	0.26	0.22
4	1464	1.06	1.32	16.10	0.26	0.87	0.51	0.13
5	1340	0.11	0.32	8.43	0.06	0.16	0.09	0.04
6	1460	0.26	0.44	20.70	0.03	0.16	0.03	0.00
7	1550	0.94	1.86	53.30	0.26	0.80	0.25	0.15
8	1580	0.69	1.87	76.70	0.12	0.35	0.14	0.04
9	1861	1.30	1.70	19.90	0.29	0.88	0.73	0.08
10	1476	0.61	1.52	56.50	0.25	0.86	0.67	0.04
11	1464	0.80	1.18	24.10	0.17	0.72	0.20	0.06
12	1481	0.74	0.84	10.21	0.13	0.67	0.22	0.01
13	1441*	0.96	0.68	8.64	0.12	0.71	0.11	0.01
14	1438	0.62	0.79	26.30	0.12	0.49	0.16	0.02
15	1011	1.13	1.55	31.10	0.37	0.86	0.54	0.14
16	1546	0.68	3.58	139.70	0.10	0.46	0.15	0.01
17	1502	0.62	1.54	14.10	0.16	0.51	0.08	0.02
18	1511	0.85	0.71	12.47	0.18	0.72	0.47	0.03
19	1486	0.94	0.89	44.10	0.22	0.99	0.45	0.02
20	1518	2.00	1.94	120.10	0.25	0.74	0.44	0.03
Average	1479	0.84	1.36	40.09	0.19	0.66	0.29	0.05

• Includes time with invalid measurements.

b) Home

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
1	1234	0.31	0.31	11.50	0.10	0.69	0.09	0.01
2	1313*	0.52	1.00	25.10	0.14	0.81	0.12	0.02
3	883	2.07	2.07	34.50	0.64	0.99	0.35	0.33
4	833	1.01	1.21	13.43	0.32	0.97	0.71	0.17
5	986	0.03	0.19	8.43	0.01	0.01	0.01	0.01
6	1460	0.26	0.44	20.70	0.03	0.16	0.03	0.00
7	1075	0.51	0.70	22.30	0.13	0.79	0.11	0.02
8	1185	0.38	0.66	29.50	0.05	0.21	0.05	0.01
9	1154	0.48	0.44	12.31	0.24	0.90	0.70	0.02
10	1170	0.59	1.66	56.50	0.26	0.92	0.74	0.03
11	726	0.74	0.77	13.90	0.13	0.77	0.15	0.04
12	620	0.74	0.43	8.06	0.15	1.00	0.14	0.00
13	847*	0.32	0.41	5.99	0.09	0.42	0.17	0.01
14	777	0.36	0.30	9.34	0.02	0.07	0.01	0.00
15	180	0.77	0.49	4.88	0.35	1.00	0.85	0.04
16	910	0.60	4.55	139.70	0.04	0.20	0.06	0.01
17	853	0.37	0.76	13.50	0.07	0.30	0.01	0.01
18	876	0.73	0.79	12.47	0.11	0.53	0.20	0.02
19	1351	0.89	0.84	44.10	0.21	1.00	0.42	0.01
20	889	1.66	1.67	7.79	0.10	0.57	0.11	0.00
Average	966	0.67	0.98	24.70	0.16	0.62	0.25	0.04

- Includes time with invalid measurements.

c) **Work**

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
3	480	0.43	0.31	8.84	0.10	0.63	0.10	0.01
4	525	0.87	0.64	10.69	0.14	0.73	0.18	0.02
5	130	0.39	0.10	1.11	0.17	0.96	0.30	0.01
9	480	3.47	1.94	19.90	0.42	1.00	0.94	0.24
11	544	0.40	0.61	20.10	0.15	0.58	0.22	0.03
12	495	0.12	0.22	5.22	0.02	0.05	0.02	0.00
13	430	1.45	0.22	3.98	0.14	0.93	0.04	0.00
14	518	0.64	0.40	11.38	0.20	1.00	0.22	0.02
15	801	1.21	1.70	31.10	0.37	0.82	0.46	0.15
16	278	0.80	0.30	6.43	0.11	0.86	0.03	0.00
17	448	0.57	0.96	10.04	0.18	0.87	0.03	0.02
18	543	0.95	0.31	9.03	0.28	1.00	0.90	0.02
20	556	2.59	1.60	87.70	0.47	1.00	0.98	0.07
Average	479	1.07	0.72	17.35	0.21	0.80	0.34	0.05

d) School

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
5	90	0.07	0.22	1.06	0.05	0.11	0.09	0.03
19	20	1.39	1.77	11.27	0.25	0.70	0.58	0.05
Average	55	0.73	1.00	6.16	0.15	0.04	0.34	0.04

e) Travel

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
1	95	1.21	5.77	59.70	0.12	0.72	0.12	0.01
2	146	1.25	1.31	14.30	0.15	0.80	0.19	0.02
3	60	1.30	1.56	14.90	0.60	0.70	0.35	0.31
4	85	2.88	3.08	16.10	0.42	0.88	0.76	0.37
5	45	0.36	0.47	2.71	0.23	0.35	0.31	0.23
7	320	1.76	3.15	53.30	0.51	0.82	0.48	0.37
8	180	0.97	2.02	32.90	0.23	0.85	0.32	0.09
9	135	0.94	1.14	10.07	0.24	0.59	0.45	0.07
10	131	0.90	0.91	10.02	0.25	0.74	0.51	0.12
11	88	1.46	1.12	11.24	0.47	0.92	0.67	0.34
12	260	1.16	0.98	10.21	0.25	0.94	0.72	0.04
13	124	1.02	0.87	8.64	0.18	0.71	0.26	0.06
14	67	1.42	1.90	26.30	0.42	0.92	0.66	0.26
15	30	1.25	1.32	11.93	0.64	1.00	0.99	0.51
16	243	0.57	0.56	8.72	0.27	0.78	0.60	0.06
17	178	1.21	2.71	14.10	0.58	0.58	0.42	0.08
18	67	0.97	1.10	11.36	0.20	0.77	0.37	0.09
19	70	1.48	1.38	11.06	0.34	0.90	0.71	0.16
20	73	1.73	4.53	120.10	0.32	0.81	0.34	0.15
Average	126	1.25	1.89	23.56	0.34	0.78	0.48	0.17

f) Other

		TWA		Peak	Harmonics			
Subject	Time, Minutes	Mean, mG	Std. Dev., mG	Peak, mG	Mean, mG	Fraction >0.1	Fraction >0.2	Fraction >0.5
1	180	0.43	0.59	8.52	0.11	0.77	0.06	0.02
2	68	0.95	1.56	11.79	0.25	0.47	0.25	0.09
4	21	0.50	0.55	3.53	0.09	0.20	0.16	0.04
5	90	0.52	0.72	7.78	0.32	0.50	0.47	0.31
7	155	2.19	2.59	46.30	0.69	0.82	0.75	0.56
8	215	2.12	4.16	76.70	0.37	0.67	0.50	0.14
9	92	0.82	0.99	9.07	0.21	0.50	0.38	0.11
10	175	0.54	0.53	8.29	0.15	0.53	0.32	0.04
11	106	2.65	2.75	24.10	0.28	0.96	0.13	0.09
12	106	2.56	0.82	5.63	0.19	0.98	0.39	0.01
13	40	0.18	0.19	0.91	0.08	0.44	0.04	0.00
14	76	2.43	1.45	7.83	0.35	0.98	0.92	0.01
16	115	1.27	2.55	9.32	0.15	0.83	0.24	0.02
17	23	6.31	4.75	11.59	0.25	0.86	0.62	0.00
18	25	2.25	0.97	4.28	0.50	0.94	0.90	0.75
19	45	1.38	0.47	3.03	0.26	0.97	0.86	0.01
Average	96	1.69	1.60	14.92	0.27	0.71	0.44	0.14

Table 7-2
Average Percentage of Time in Environments for All Subjects *

Environment	Pilot Study	ARB Study[1]
Home	64	65
Work	21	
School	0	
Other	5	
Away from Home†	27	28
Travel	8	8

* Totals may differ from 100% due to rounding.
† ARB Study: Away from Home includes 4 minutes with location unknown.

1 Wiley et al., 1991b

Table 7-3
Estimated Total TWA, Peak, and Harmonic Exposures by Subject for TWA Source Factor = 0.05 and Peak Source Factor = 0.01

	TWA[1]				Harmonics		
Subject	Median, mG	5th, mG	95th, mG	Peak[2], mG	Fraction > 0.1	Fraction > 0.2	Fraction > 0.5
1	0.76	0.42	1.35	27.42	0.88	0.06	0.00
2	1.17	0.62	3.03	54.13	0.77	0.24	0.00
3	1.32	0.56	3.53	54.13	0.64	0.12	0.00
4	1.76	0.76	5.55	58.51	0.36	0.22	0.00
5	0.51	0.16	1.11	99.79	0.07	0.01	0.00
6	1.02	0.52	2.90	25.63	0.77	0.31	0.00
7	1.01	0.54	2.57	27.42	0.78	0.33	0.00
8	1.05	0.62	2.83	38.23	0.85	0.29	0.03
9	1.31	0.63	2.89	58.45	0.66	0.11	0.01
10	0.85	0.39	2.96	29.39	0.88	0.17	0.00
11	1.44	0.58	5.69	60.44	0.56	0.46	0.00
12	1.39	0.61	5.32	57.26	0.51	0.42	0.00
13	1.29	0.55	3.34	54.13	0.64	0.21	0.00
14	1.01	0.61	2.38	57.26	0.59	0.10	0.00
15	1.40	0.54	4.05	54.13	0.36	0.09	0.00
16	1.22	0.65	2.68	57.26	0.61	0.37	0.00
17	1.12	0.63	2.50	54.13	0.62	0.16	0.00
18	1.20	0.52	2.68	54.13	0.48	0.03	0.00
19	0.63	0.37	2.06	27.42	0.61	0.09	0.00
20	1.53	0.81	3.18	54.13	0.59	0.15	0.00

1 TWA source factor = 0.05
2 Peak source factor = 0.01

Table 7-4
Sensitivity of Overall TWA Exposure to Model Inputs by Subject by TWA Source Factor

Source Factor	1		0.05	
Subject	Input	Beta Coeff.	Input	Beta Coeff.
1	Inside-UG	0.89	Inside-UG	0.93
	Other-default	0.27	Other-default	0.29
	Sources	0.25	Travel-OH	0.16
	Travel-OH	0.15	Home-age	0.14
	Home-age	0.13	2-prong outlets	0.11
	2-prong outlets	0.10	Sources	0.02
2	Inside-OH	0.83	Inside-OH	0.83
	Work: 3800	0.60	Work: 3800	0.59
	Outside-OH	0.04	Outside-OH	0.04
	Home-size	0.03	Home-size	0.03
	Travel-OH	0.03	Travel-OH	0.03
	Home-age	0.03	Home-age	0.03
	Kitchen	0.02	Kitchen	0.02
	2-prong outlets	0.02	2-prong outlets	0.02
	Sources	0.02		
3	Work: 7100	0.85	Work: 7100	0.85
	Inside-OH	0.49	Inside-OH	0.50
	Multiple-family unit	0.04	Multiple-family unit	0.04
	Sources	0.03	Travel-OH	0.03
	Travel-OH	0.03	Home-size	0.02
	Home-size	0.02	Kitchen	0.01
	Kitchen	0.01	Sources	0.00
4	Work: 6100	0.99	Work: 6100	0.99
	Inside-OH	0.15	Inside-OH	0.13
	Outside-OH	0.05	Outside-OH	0.04
	Travel-OH	0.04	Travel-OH	0.03
	Sources	0.03	Other-default	0.01
	Other-default	0.01	Home-size	0.01
	Home-size	0.01	Home-age	0.00
	Home-age	0.01	Kitchen	0.00
	Kitchen	0.00	Sources	0.00
	Inside-UG	0.00	Inside-UG	0.00

Source Factor	1		0.05	
Subject	Input	Beta Coeff.	Input	Beta Coeff.
5	Inside-UG	0.94	Inside-UG	0.94
	Work: 2000	0.21	Work: 2000	0.21
	Other-default	0.17	Other-default	0.17
	H2O well	-0.16	H2O well	-0.16
	Travel-rural	0.12	Travel-rural	0.12
	Outside-rural	0.06	Outside-rural	0.05
	Sources	0.05		
6	Inside-OH	0.89	Inside-OH	0.99
	Outside-OH	0.34	Outside-OH	0.22
	Sources	0.33	Home-size	0.04
	Home-age	0.03	Home-age	0.04
	Home-size	0.03	2-prong outlets	0.02
	2-prong outlets	0.03	Kitchen	0.01
	Kitchen	0.02		
7	Inside-OH	0.94	Inside-OH	0.96
	Travel-OH	0.28	Travel-OH	0.24
	Other-default	0.10	Other-default	0.08
	Outside-OH	0.09	Outside-OH	0.08
	Sources	0.08	Multiple-family unit	0.08
	Multiple-family unit	0.08	Home-size	0.04
	Home-size	0.04	Kitchen	0.01
	Kitchen	0.01		
8	Inside-OH	0.96	Inside-OH	0.98
	Sources	0.18	Travel-OH	0.13
	Travel-OH	0.14	Multiple-family unit	0.08
	Multiple-family unit	0.08	Other-default	0.06
	Other-default	0.07	Outside-OH	0.04
	Outside-OH	0.05	Home-size	0.04
	Home-size	0.04	Other-grocery	0.03
	Other-grocery	0.03	Kitchen	0.01
	Kitchen	0.01	Inside-UG	0.01
	Inside-UG	0.01	Sources	0.01
9	Inside-OH	0.80	Inside-OH	0.86
	Work: 4300	0.57	Work: 4300	0.50
	Sources	0.12	Travel-OH	0.07
	Travel-OH	0.08	Other-default	0.03
	Other-default	0.03	Inside-UG	0.01
	Inside-UG	0.01	Other-grocery	0.01
	Other-grocery	0.00	Kitchen	0.00
	Kitchen	0.00		

Source Factor	1		0.05	
Subject	Input	Beta Coeff.	Input	Beta Coeff.
10	Inside-OH	0.97	Inside-OH	0.99
	Sources	0.19	Travel-OH	0.07
	Travel-OH	0.10	Other-default	0.07
	Other-default	0.09	Outside-OH	0.01
	Outside-OH	0.02	Inside-UG	0.01
	Inside-UG	0.02	Kitchen	0.01
	Kitchen	0.01		
11	Inside-transmission line	0.87	Inside-transmission line	0.87
	Work: 1700	0.51	Work: 1700	0.52
	Other-default	0.03	Other-default	0.03
	Travel-OH	0.02	Travel-OH	0.02
	Home-age	0.01	Home-age	0.01
	Kitchen	0.00	Kitchen	0.00
12	Inside-transmission line	0.83	Inside-transmission line	0.83
	Work: 1700	0.54	Work: 1700	0.54
	Travel-OH	0.07	Travel-OH	0.07
	Other-default	0.03	Other-default	0.03
	Home-age	0.01	Home-age	0.01
	Kitchen	0.00	Kitchen	0.00
13	Work: 4647	0.87	Work: 4647	0.87
	Inside-OH	0.54	Inside-OH	0.53
	Travel-OH	0.06	Travel-OH	0.06
	Home-age	0.02	Home-age	0.02
	Outside-OH	0.02	Outside-OH	0.02
	Kitchen	0.01	Kitchen	0.01
14	Inside-OH	0.96	Inside-OH	0.96
	Work: 1900	0.26	Work: 1900	0.26
	Other-default	0.07	Other-default	0.07
	Travel-OH	0.06	Travel-OH	0.06
	Home-age	0.04	Home-age	0.04
	2-prong outlets	0.03	2-prong outlets	0.03
	Sources	0.01	Kitchen	0.01
	Kitchen	0.01	Home-size	0.00
	Home-size	0.00		
15	Work: 1700	0.97	Work: 1700	0.97
	Inside-OH	0.25	Inside-OH	0.25
	Travel-OH	0.05	Travel-OH	0.05
	Home-age	0.01	Home-age	0.01
	2-prong outlets	0.01	2-prong outlets	0.01
	Home-size	0.00	Home-size	0.00

Source Factor	1		0.05	
Subject	Input	Beta Coeff.	Input	Beta Coeff.
16	Work: 4647	0.81	Work: 4647	0.83
	Inside-OH	0.51	Inside-OH	0.52
	Sources	0.16	Outside-OH	0.14
	Outside-OH	0.13	Travel-OH	0.12
	Travel-OH	0.12	Other-default	0.04
	Other-default	0.04	Home-size	0.02
	Home-size	0.02	Home-age	0.02
	Home-age	0.02	Sources	0.02
	2-prong outlets	0.01	2-prong outlets	0.01
	Inside-UG	0.01	Inside-UG	0.01
	Kitchen	0.01	Kitchen	0.01
17	Inside-OH	0.87	Inside-OH	0.87
	Work: 1800	0.44	Work: 1800	0.44
	Travel-OH	0.09	Travel-OH	0.09
	Outside-OH	0.07	Outside-OH	0.07
	Home-size	0.04	Home-size	0.03
	Home-age	0.03	Home-age	0.03
	2-prong outlets	0.02	2-prong outlets	0.02
	Inside-UG	0.01	Inside-UG	0.01
	Kitchen	0.01	Kitchen	0.01
18	Inside-OH	0.80	Work: 1400	0.81
	Work: 1400	0.61	Inside-OH	0.60
	Sources	0.06	Travel-OH	0.03
	Travel-OH	0.05	Home-age	0.02
	Home-age	0.03	2-prong outlets	0.02
	2-prong outlets	0.02	Home-size	0.00
	Home-size	0.00		
19	Inside-OH	1.00	Inside-OH	1.00
	Travel-OH	0.06	Travel-OH	0.06
	Other-default	0.04	Other-default	0.04
	Home-size	0.04	Home-size	0.04
	Home-age	0.04	Home-age	0.04
	2-prong outlets	0.02	2-prong outlets	0.02
	Outside-OH	0.02	Outside-OH	0.02
20	Inside-OH	0.70	Inside-OH	0.70
	Work: 4300	0.67	Work: 4300	0.67
	Travel-OH	0.04	Travel-OH	0.04
	Home-size	0.03	Home-size	0.03
	Home-age	0.03	Home-age	0.03
	2-prong outlets	0.02	2-prong outlets	0.02
	Kitchen	0.01	Kitchen	0.01

8

DISCUSSION AND CONCLUSIONS

8.1 Field level component

The model demonstrated the importance of representative empirical field distributions for estimating magnetic field exposures. Such distributions are based on a substantial number of measurements in a large number of houses or by a large number of people in different settings. Although field values based on measurements from a small sample or limited geographical region may produce exposure estimates with little uncertainty for the sampled populations, they do not capture the broad diversity for exposure components that are discernible through a diary or interview.

Lack of data on field levels and, more importantly, their distributions for environments and near sources dictated the assumption of arbitrary levels and hypothetical distributions with limited and, occasionally, no support in the literature. These assumptions are necessary when field distributions based on large measurement samples are not available. Use of assumed values and distributions was often required for the Travel and Other environments, peak and harmonic parameters, and the choice of source factors.

Although sources tend not to be important contributors to TWA exposure, they can significantly influence it in some circumstances and they definitely affect peak exposure. Additional data related to sources is needed in two areas to ensure proper treatment of them in the model. First, more information on the spatial distribution of fields from sources would enhance the quality of field estimates for both TWA-exposure and peak-exposure distances. Second, additional data is needed on the fields produced by a wider variety of sources of each type (more hair dryers, sewing machines, etc.), while focusing on the sources' age and design. Satisfying these two needs would enable appropriate source factors in the model to account for spatial averaging and the exposure of interest.

The quality of TWA exposure estimates in the Work environment was limited by the nature of the job-exposure-matrix approach used to assign fields to this time period. The exposure model was based on point estimates and an assumed distribution for the TWA exposures within each job category. Ideally, the Work environment would be treated in the same manner as the Home environment, with field distributions for baseline fields, adjustments, and sources. However, characterization of these distributions in the Work environment is currently limited to a few location and source types and, even if these model inputs were identified, they might not be amenable to identification through diary and/or interview.

Exposure estimates in the Travel and Other environments are also hampered by the use of often arbitrary and hypothetical field distributions for many inputs. In addition, these environments have few inputs, resulting in comparable exposures across many individuals, whose measured exposures may differ significantly. The identification and characterizations of additional inputs for the Travel and Other environments is warranted. Incorporation of empirical field distributions for travel by electric-vehicle modes of transportation seems appropriate given the high fields and the length of commutes.

The model was undertaken to develop a technique for estimating exposure and to use existing data to demonstrate its performance. One result of such an exercise is the identification of shortcomings in the breadth and depth of the data available for use in the model. The model estimates presented here for the pilot study should be considered strictly in that context - a small unrepresentative sample of measured exposures and model estimates hampered by shortcomings n the data available to the model.

8.2 Time-activity Component

The time information obtained with either a concurrent or retrospective diary appears to be adequate for modeling purposes. The uncertainties in time information are insignificant compared to those associated with the field levels and distributions of the modeled inputs. The variability in time information would be more significant when estimates are attempted for groups or for a subject's typical day. When modeling those exposures, the uncertainties introduced by probability distributions for time spent in environments or using sources will only increase the overall variability of estimates resulting from field distributions.

Eliciting information for the model from subjects via interview is inherently limited to that which the subject can discern. Thus information that would contribute to more narrow distributions for the model inputs are often not available; for example, whether ground currents are present at a subject's home. In addition the detail needed from the subject to narrow the field distributions may not lend itself to an interview. For example, it is not practical to obtain a precise time-course for the use of multiple appliances while cooking. Such data could identify concurrent use of appliances and could justify combining estimated exposures.

8.3 Implementation

The computational model was successfully implemented on a spreadsheet working in concert with a commercial modeling software package. The model had the ability to introduce distributions for model inputs and the system permitted the use of empirical distributions for inputs whose distributions are known. This approach limited the arbitrary selection of distributions to those inputs for which data were not readily available.

Comfort with the model is greatest for the TWA which reflects a physical quantity that can be readily measured and, except for uncertainty in spatial averaging, is limited only by the available data. Modeling of peak values requires identifying through interviews the conditions of a one-time event and estimating a proper exposure, a difficult task. In modeling harmonic-field exposures, or other status-related (yes/no, low/medium/high) parameters, the entire block of time associated with an environment or source is assigned to one status. This is in contrast with measurements where the status can be discerned for each measurement. The difficulty of modeling this sort of parameter falls somewhere between the relative ease of an integrated parameter (TWA) and the more demanding one-time event parameter (peak).

8.4 Pilot Study

The pilot study provided a very limited sample of subjects, which was adequate for implementation of the model but severely constrained its verification. The pilot also demonstrated the adequacy of both a retrospective and concurrent diary when combined with an interview to collect time, location, and source usage from the subjects.

Data from the limited pilot study indicated that:

- the model responded to changes in field levels, time or status as expected;
- the estimated exposures were generally greater than the measured exposures for all three field parameters;
- there are large uncertainties in modeling the contribution of sources to TWA and peak exposures;
- estimated TWA exposure in the model is most strongly influenced by field levels inside the home and at work (for this limited sample no subjects had significant time at school); and

- the field distributions associated with the environment categories in the model (e. g., underground and overhead lines) are too broad to provide useful estimates of individual exposures.

8.5 General observations

The principal impediment to models of this type appears to be the lack of discernible categories that define narrow magnetic field distributions for environments and sources. Efforts to improve models must address or circumvent the excessive variability in exposure predictors.

To assess the exposure of a single individual, some simple survey or PE measurements will do much more to improve the precision of estimated exposure for an individual than will additional information about subject, environment or source attributes obtained from a questionnaire and/or interview.

Since TWA exposures are largely driven by where a person spends the most time, distributions of estimated exposure in a model can be narrowed by significantly improving the estimates of fields in these few environments, say Home, Work or School. It is unlikely that the subject can provide information about an environment that will accomplish this. As a consequence, measurements to improve the characterization of exposure for an individual beyond that achieved with broad empirical probability distributions will be required only in a few locations.

The modeling approach presented here is likely to be more appropriate for estimating exposures of large groups rather than individuals. For groups, the broad distribution of exposures inherent in a model of this type are expected. This model may also be appropriate for investigating the relative sensitivity of exposures to different exposure factors.

Based on limited application of this model, we conclude that it is unlikely that improvements to models of this type will be of sufficient value for them to be used as predictors of individual exposure. The model necessarily employs the broad field distributions based on factors that are discernible by a subject and from whom information can be obtained by interview. Limited on-site field measurements are preferable for reducing the uncertainty in estimating magnetic-field exposure.

9

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D. Lanera, J. E. Zapotosky, and J. A. Colby, "Study of Magnetic Fields from Power-Frequency Current On Water Lines," *Bioelectromagnetics.* Vol. 18, No. 4, pp. 307-316 (1997).

D. L. Mader and S. B. Peralta, "Residential Exposure to 60-Hz Magnetic Fields from Appliances," *Bioelectromagnetics.* Vol. 13, pp. 287-301 (1992).

Palisade Corporation. *@Risk Advanced Risk Analysis for Spreadsheets.* Palisade Corporation, Newfield, NY 1997.

J. M. Silva and T. D. Marshall. *Magnetic Fields in Schools: Sources and Management.* ENERTECH Consultants, Campbell, CA 19??

M. Silva, L. Zaffanella, and N. Hummon, "An Activity Systems Model for Estimating Human Exposure to 60 Hz Electric Fields," *IEEE Transactions on Power Apparatus and Systems.* Vol. 104, No. 7, pp. 1923-1929 (1985).

W. Sun, P. Heroux, T. Clifford, F. Hamade, and V. Sadilek. "Characterization of ELF Magnetic Fields in Carleton Board of Education Schools," *in: Project Abstracts: The Annual Review of Research On Biological Effects of Electric and Magnetic Fields from the Generation, Delivery & Use of Electricity.* W/L Associates Ltd., Editor. W/L Associates, Ltd., Frederick, MD 1994, p. 30.

J. A. Wiley, J. P. Robinson, Y. T. Cheng, T. Piazza, L. Stork, and K. Pladsen. *Study of Children's Activity Patterns.* Contract No. A733-149, Final Report, September 1991. California Environmental Protection Agency, Sacramento 1991a.

J. A. Wiley, J. P. Robinson, T. Piazza, K. Garrett, K. Cirksena, Y. T. Cheng, and G. Martin. *Activity Patterns of California Residents.* Contract No. A6-177-33, Final Report, May 1991. California Environmental Protection Agency, Sacramento 1991b.

B. W. Wilson, N. H. Hansen, and K. C. Davis, "Magnetic-Field Flux Density and Spectral Characteristics of Motor-Driven Personal Appliances," *Bioelectromagnetics.* Vol. 15, No. 5, pp. 439-446 (1994).

M. G. Yost, J. A. Touchstone, M. Wrensch, R. Miike, S. E. Carozza, and J. D. Bowman (1997): Development of a population based job-exposure matrix for 60 Hz magnetic fields. Poster presented at the biological effects meeting in San Diego, November, 1997.

L. E. Zaffanella. *Survey of Residential Magnetic Field Sources.* EPRI TR-102759-V1, Project 3335-02. Electric Power Research Institute, Palo Alto, CA 1993.

L. E. Zaffanella. *Magnetic Fields in Schools, Sources and Mitigation.* Paper given at Seminar on EMF of the New York State Insurance Reciprocal, March 2, 1995 (Cited in Zaffanella, 1996). Enertech, Lee, MA 1995.

L. E. Zaffanella. *Environmental Field Surveys: EMF RAPID Program Engineering Project #3.* Enertech Consultants, Lee, MA 1996.

L. E. Zaffanella and G. W. Kalton. *Survey of Personal Magnetic Field Exposure. Phase II: 1000-Person Survey Interim Report. EMF RAPID Program Engineering Project #6.* Enertech Consultants, Lee, MA 1998.

APPENDIX A

MAGNETIC FIELD MEASUREMENTS CITATION DATABASE

The citation database contains summaries of reports of magnetic field measurements studies encountered during a comprehensive review of the literature. Each record in the database summarizes a single report and there are a total of 231 records. Fields in each record include: author, year of publication, title, citation, sample site, industry targeted (if applicable), time period of measurements, and geographic area. Also included are a collection of binary (yes/no) fields which record whether the study addressed one of a collection of factors applicable to modeling exposure. In all, 36 fields are present in a record. (Selected sample records are presented at the end of this appendix.) This appendix continues with an alphabetized listing, by author, of the author, year, title, and citation of each report in the citation database.

Citations A-1
Sample Records A-31

Author: Agnew,DA
Year: 1994
Title: Assessment of occupational exposure to 60 Hz electric and magnetic fields
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates, W/L Associates, Ltd., Frederick, MD, A-38, 38-39

Author: Akbar-Khanzadeh,F, Huffman,JR
Year: 1995
Title: Office workers' exposure to extremely low frequency (ELF) magnetic fields and their perception of characteristics and health effects of ELF electromagnetic fields
Citation: Applied Occupational and Environmental Hygiene.10(11):927-933

Author: Anderson,FJ, Phillips,BG
Year: 1984
Title: Electric field strengths and magnetic flux densities around electric power generating and distribution facilities in Alberta
Citation: Alberta Workers' Health, Safety & Compensation, Edmonton

Author: Armanini,D, Conti,R, Mantini,A, Nicolini,P
Year: 1990
Title: Measurements of power-frequency electric and magnetic fields around different industrial and household sources
Citation: CIGRE, Paris

Author: Armanini,D, Conti,R, Mantini,A, Nicolini,P
Year: 1990
Title: Measurements of power-frequency electric and magnetic fields around different industrial and household sources
Citation: CIGRE, Paris

Author: Armstrong,B, Th,riault,G, Gu,nel,P, Deadman,J, Goldberg,M, Heroux,P
Year: 1994
Title: Association between exposure to pulsed electromagnetic fields and cancer in electric utility workers in Quebec, Canada, and France
Citation: American Journal of Epidemiology 140():805-820

Author: Armstrong,BG, Deadman,JE, Th,riault,G
Year: 1990
Title: Comparison of indices of ambient exposure to 60-hertz electric and magnetic fields
Citation: Bioelectromagnetics 11():337-347

Author: Auger,G
Year: 1994
Title: Measurements of 50 Hz magnetic fields from infant incubators and heating beds
Citation: Abstract presented at the DOE's and others' Contractor review meeting, Albequerque, NM

Author: Bangay,MJ, Delpizzo,V, Borghesi,JL
Year: 1993
Title: Spectral measurements of residential ELF magnetic fields
Citation: Australian Radiation Laboratory, Yallambie, Victoria, Australia

Author: Barnes,F, Wachtel,H, Savitz,D, Fuller,J
Year: 1989
Title: Use of wiring configuration and wiring codes for estimating externally generated electric and magnetic fields
Citation: Bioelectromagnetics 10():13-21

Author: Barroetavena,M, Ross,R, Teschke,K
Year: 1994
Title: Electric and magnetic fields at three pulp and paper mills
Citation: American Industrial Hygiene Association Journal 55(4):358-363

Author: Bearer,C
Year: 1994
Title: Electromagnetic fields and infant incubators
Citation: Archives of Environmental Health 49(5):352-354

Author: Berglund,A, Mild,KH
Year: 1992
Title: Intermittent exposure--a question of sampling rate
Citation: National Institute of Occupational Health, Department of Occupational Medicine, Umea, Sweden

Author: Berglund,A, Mild,KH
Year: 1992
Title: Intermittent exposure--a question of sampling rate
Citation: National Institute of Occupational Health, Department of Occupational Medicine, Umea, Sweden

Author: Berisha,SH, Karady,GG, Hobbs,R, Karner,D, Clark,J
Year: 1995
Title: Characterization of magnetic field generated from electric vehicles
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates Ltd., W/L Associates, Ltd., Frederick, MD, P-36, 90-92

Author: Bitran,M, Charron,D, Nishio,J
Year: 1995
Title: Background ELF magnetic fields in Ontario offices
Citation: Ontario Ministry of Labour, Occupational Health and Safety Branch, Toronto

Author: Borghesi,JL, Delpizzo,V
Year: 1994
Title: Development and evaluation of a location-specific wire code
Citation: Bioelectromagnetics 15():337-347

Author: Bowman,JD, Garabrant,DH, Sobel,E, Peters,JM
Year: 1988
Title: Exposures to extremely low frequency (ELF) electromagnetic fields in occupations with elevated leukemia rates
Citation: Applied Industrial Hygienics 3():189-194

Author: Bowman,JD, Sobel,E, London,SJ, Thomas,DC, Garabrant,DH, Pearce,N, Peters,JM
Year: 1992
Title: Electric and magnetic field exposure, chemical exposure, and leukemia risk in 'electrical' occupations. Final Report TR-101723
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Bracken,MB, Belanger,K, Hellenbrand,K, Dlugosz,L, Holford,TR, McSharry,J-E, Addesso,K, Leaderer,B
Year: 1995
Title: Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: Association with birthweight and intrauterine growth retardation
Citation: Epidemiology 6(3):263-270

Author: Bracken,TD
Year: 1976
Title: Field measurements and calculations of electrostatic effects of overhead transmission lines
Citation: IEEE Transactions on Power Apparatus and Systems 95():494-504

Author: Bracken,TD
ear: 1986
nalysis of BPA occupational electric field exposure data
Citation: Bonneville Power Administration, Vancouver, WA

Author: Bracken,TD
Year: 1988
Title: Measurement of occupational exposure of substation workers to 60-Hz magnetic fields
Citation: Bonneville Power Administration, Vancouver, WA

Author: Bracken,TD
Year: 1990
Title: The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Bracken,TD
Year: 1993
Title: Program to monitor electric and magnetic fields and ions before and after energization of a ñ450 kV HVDC transmission line in New Hampshire. Fourth annual (and final) report: For the period January, 1992 - October, 1992
Citation: T. Dan Bracken, Inc., Portland, OR

Author: Bracken,TD
Year: 1994
Title: Electric and magnetic fields in a magnetic resonance imaging facility: Measurements and exposure assessment procedures. Prepared for National Institute for Occupational Safety and Health (NIOSH R/PR No. 124 VOG)
Citation: National Institute of Occupational Safety and Health; National Technical Information Service, Arlington, VA

Author: Bracken,TD, Bailey,WH, Charry,JM
Year: 1985
Title: Evaluation of the DC electrical environment in proximity to VDTs
Citation: Journal of Environmental Science and Health A20():745-780

Author: Bracken,TD, Capon,AS, Montgomery,DV
Year: 1978
Title: Ground level electric fields and ion currents on the Celilo-Sylmar +-400 kV DC intertie during fair weather
Citation: Bonneville Power Administration, Portland, OR

Author: Bracken,TD, Rankin,R, Dickson,L
Year: 1994
Title: Magnetic and Electric Field Survey in the Auto Industry
Citation: UAW/Chrysler National Training Center, Detroit, MI

Author: Bracken,TD, Rankin,RF, Senior,RS, Alldredge,JR
Year: 1994
Title: The EMDEX Project: Residential Study, Final Report
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Breysse,P, Lees,PSJ, McDiarmid,MA, Curbow,B
Year: 1994
Title: ELF magnetic field exposures in an office environment
Citation: American Journal of Industrial Medicine 25():177-185

Author: Breysse,P, Matanoski,G, Elliott,E, Francis,M, Kaune,W, Thomas,K
Year: 1994
Title: 60 hertz magnetic field exposure assessment for an investigation of leukemia in telephone lineworkers
Citation: American Journal of Industrial Medicine 26():681-691

Author: Breysse,P, Matanoski,G, Elliott,E, Francis,M, Kaune,W, Thomas,K
Year: 1994
Title: 60 hertz magnetic field exposure assessment for an investigation of leukemia in telephone lineworkers
Citation: American Journal of Industrial Medicine 26():681-691

Author: Broadbent,DE, Broadbent,MHP, Male,JC, Jones,MRL
Year: 1985
Title: Health of workers exposed to electric fields
Citation: British Journal of Industrial Medicine 42(?):75-84

Author: Caola,RJ, Deno,DW, Dymek,VSW
Year: 1983
Title: Measurements of electric and magnetic fields in and around homes near a 500 kV transmission line
Citation: IEEE Transactions on Power Apparatus and Systems 102():3338-3347

Author: Cartwright,CE, Breysse,PN, Booher,L
Year: 1993
Title: Magnetic field exposures in a petroleum refinery
Citation: Applied Occupational and Environmental Hygiene 8(6):587-592

Author: Coleman,M, Bell,CMJ, Taylor,H-L, Thorton-Jones,H
Year: 1985
Title: Leukaemia and electromagnetic fields: A case-control study
Citation: Institute of Electrical Engineers, London

Author: Conrad,SA
Year: 1994
Title: An examination of extremely low frequency electric and magnetic fields in the semiconductor industry
Citation: SSA Journal ?():18-24

Author: Cummings,DO, Robertson,DC
Year: 1990
Title: Preliminary results of magnetic flux density measurements on TR07 vehicle and maglev system at Emsland
Citation: Project resumes: the annual review of research on biological effects of 50 & 60 Hz electric and magnetic fields. (Held 5-8 November 1990, Denver, CO. Organized by U.S. Department of Energy, Office of Energy Management. Co-sponsors: American Public Power Association, Washington, DC and Edison Electric Institute, Washington, DC.), W/L Associates Ltd., W/L Associates Ltd., Frederick, MD,, A12

Author: Daily,WK, Dawalibi,F
Year: 1994
Title: Measurements and computations of electromagnetic fields in electric power substations
Citation: IEEE Transactions on Power Delivery 9():324-333

Author: Daley,ML, Morton,WE, Chartier,V, Zajac,H, Benitez,H
Year: 1985
Title: Community fear of nonionizing radiation: A field investigation
Citation: IEEE Transactions on Biomedical Engineering BME-32():246-248

Author: Deadman,JE, Camus,M, Armstrong,BG, Heroux,P, Cyr.D, Plante,M, Th,riault,G
Year: 1988
Title: Occupational and residential 60-Hz electromagnetic fields and high frequency electric transients: exposure assessment using a new dosimeter
Citation: American Industrial Hygiene Association Journal 49(8):409-419

Author: Delpizzo,V
Year: 1991
Title: The use of body-worn dosimeters in occupational magnetic field exposure assessment
Citation: Bioelectromagnetic Society Thirteenth Annual Meeting abstract book. (June 23-27, 1991, Salt Lake City, UT), The Bioelectromagnetic Society, The Bioelectromagnetic Society, Frederick, MD,, 14

Author: Delpizzo,V
Year: 1992
Title: An apparently incongruous exposure-response relationship resulting from the use of job description to assess magnetic field exposure
Citation: Scandinavian Journal of Work, Environment and Health 18(4):242-245

Author: Delpizzo,V, Borghesi,JL, Salzberg,MR, Farish,SJ
Year: 1991
Title: Retrospective assessment of ELF occupational exposure
Citation: The Bioelectromagnetic Society Thirteenth Annual Meeting abstract book, The Bioelectromagnetic Society, The Bioelectromagnetic Society, Frederick, MD, A-2-15, 13-14

Author: Delpizzo,V, Salzberg,MR, Farish,SJ
Year: 1990
Title: Magnetic field exposure misclassification associated with various spot measurement protocols
Citation: Bioelectromagnetics Society, Frederick, MD

Author: Deno,DW
Year: 1976
Title: Transmission line fields
Citation: IEEE, New York

Author: Deno,DW, Silva,M
Year: 1984
Title: Method for evaluating human exposure to 60 Hz electric fields
Citation: IEEE Transactions on Power Apparatus and Systems 103():1699-1706

Author: Dietrich,FM et al.
Year: 1993
Title: Magnetic and electric field testing of the Amtrak Northeast Corridor, and New Jersey Transit/North Jersey Coastline Rail System
Citation: U.S. Department of Transportation, Washington, DC

Author: Dietrich,FM, Feero,WE, Jacobs,WL
Year: 1993
Title: Safety of high speed guided ground transportation systems: Comparison of magnetic and electric fields of conventional and advanced electrified transportation systems
Citation: U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, DC

Author: Dietrich,FM, Feero,WE, Robertson,DC, Sicree,RM
Year: 1992
Title: Measurement of power system magnetic fields by waveform capture
Citation: EPRI, Palo Alto, CA

Author: Dlugosz,L, Belanger,K, Johnson,P, Bracken,MB
Year: 1994
Title: Human exposure to magnetic fields: A comparative assessment of two dosimeters
Citation: Bioelectromagnetics 15():593-597

Author: Dlugosz,LJ, Byers,T, Vena,J, Zielezny,M
Year: 1989
Title: Ambient 60-Hz magnetic flux density in an urban neighborhood
Citation: Bioelectromagnetics 10():187-196

Author: Donnelly,KE, Agnew,DA
Year: 1991
Title: Results from a comparison study of 60-Hz magnetic field exposure assessment methods for residences
Citation: Project resumes: The annual review of research on biological effects of 50 and 60 Hz electric and magnetic fields, Milwaukee, Wisconsin 30-7 November, 1991, W/L Associates Ltd., W/L Associates Ltd., Frederick, MD,, A-35

Author: Dovan,T, Kaune,WT, Savitz,DA
Year: 1993
Title: Repeatability of measurements of residential magnetic fields and wire codes
Citation: Bioelectromagnetics 14():145-159

Author: EPRI
Year: 1991
Title: Pilot study of nonresidential power frequency magnetic fields
Citation: Electric Power Research Institute, Palo Alto, CA

Author: ESEERCO
Year: 1989
Title: Magnetic field levels associated with 345 kV transmission circuits in New York State
Citation: Empire State Electric Energy Research Corporation (Ed.), New York

Author: Fenster,RM, Paz,JD, Lamb,JM
Year: 1995
Title: Electromagnetic profile in commercial and corporate aircraft
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates Ltd., W/L Associates, Ltd., Frederick, MD, P-35, 90

Author: Feychting,M, Ahlbom,A
Year: 1992
Title: Magnetic fields and cancer in people residing near Swedish high voltage power lines
Citation: Institutet for miljomedicin, Karolinska Institutet, Stockholm

Author: Feychting,M, Ahlbom,A
Year: 1993
Title: Magnetic fields and cancer in children residing near Swedish high-voltage power lines
Citation: American Journal of Epidemiology 138():467-481

Author: Floderus,B, Persson,T, Stenlund,C, Linder,G, Johansson,C, Kiviranta,J, Parsman,H, Lindblom,M, Wennberg,A, Ost,A, Knave,B
Year: 1992
Title: Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors: A case-control study
Citation: Litohuset, Stockholm

Author: Floderus,B, Persson,T, Stenlund,C, Wennberg,A, Ost,A, Knave,B
Year: 1993
Title: Occupational exposure to electromagnetic fields in relation to leukemia and brain tumors: a case-control study in Sweden
Citation: Cancer Causes and Control 4():465-476

Author: Florig,HK
Year: 1986
Title: Population exposure to power-frequency fields. PhD. Dissertation 1986
Citation: Carnegie-Mellon University, Pittsburgh, PA

Author: Florig,HK, Hoburg,JF
Year: 1990
Title: Power-frequency magnetic fields from electric blankets
Citation: Health Physics 58(4):493-502

Author: Flynn,MR, West,S, Kaune,WT, Savitz,DA, Chen,C-C, Loomis,DP
Year: 1991
Title: Validation of expert judgment in assessing occupational exposure to magnetic fields in the utility industry
Citation: Applied Occupational and Environmental Hygiene 6(2):141-145

Author: Friedman,DR, Hatch,EE, Tarone,R, Kaune,WT, Kleinerman,RA, Wacholder,S, Boice Jr.,JD, Linet,MS
Year: 1996
Title: Childhood exposure to magnetic fields: Residential area measurements compared to personal dosimetry
Citation: Epidemiology 7(2):151-155

Author: Fulcomer,PM
Year: 1985
Title: NBS ambient magnetic field meter for measurement and analysis of low-level power frequency magnetic fields in air
Citation: US Department of Energy, Washington, DC

Author: Fulton,JP, Cobb,S, Preble,L, Leone,L, Forman,E
Year: 1980
Title: Electrical wiring configurations and childhood leukemia in Rhode Island
Citation: American Journal of Epidemiology 1980():292-296

Author: Gamberale,F, Anshelm Olson,B, Eneroth,P, Lindh,T, Wennberg,A
Year: 1989
Title: Acute effects of ELF electromagnetic fields: a field study of linesmen working with 400 kV power lines
Citation: British Journal of Industrial Medicine 46(10):729-737

Author: Gauvin,D, Levallois,P, Gingras,S
Year: 1993
Title: EMF exposure assessment for office employees: a pilot study
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates, W/L Associates, Ltd., Frederick, MD, P-28, 49-50

Author: General Electric Company
Year: 1989
Title: Pilot study of residential power frequency magnetic fields
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Guenel,P, Nicolau,J, Imbernon,E, Chevalier,A, Goldberg,M
Year: 1996
Title: Exposure to 50-Hz electric field and incidence of leukemia, brain tumors, and other cancers among French electric utility
Citation: American Journal of Epidemiology 144():1107-1121

Author: Guenel,P, Nicolau,J, Imbernon,E, Warret,G, Goldberg,M
Year: 1993
Title: Design of a job exposure matrix on electric and magnetic fields: Selection of an efficient job classification for workers in thermoelectric power production plants
Citation: International Journal of Epidemiology 22(6):S16-S21

Author: Guttman,JL, Zaffanella,LE, Johnson,GB
Year: 1994
Title: Survey measurements and experimental studies of residential transient magnetic fields
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Hansen,NH, Gillette,L, Sobel,E, Davanipour,Z, Wilson,BW
Year: 1995
Title: Measurement and spectral characterization of magnetic fields in the garment industry
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates Ltd., W/L Associates, Ltd., Frederick, MD, A-35, 38-39

Author: Harris,EL, Rindall,BD, Tarko,NJ, Norris-Elye,OC
Year: 1992
Title: The effect of a helicopter on DC fields and ions
Citation: IEEE, New York

Author: Harvey,SM, Starecky,L
Year: 1984
Title: Survey of electric and magnetic fields at Ontario Hydro VDU work stations
Citation: Video display units--Characterization of electric and magnetic fields, Walsh,ML, Ontario Hydro, Toronto, 4, 81-98

Author: Hayashi,N, Isaki,K, Yokoi,Y
Year: 1989
Title: ELF electromagntic environment in power substations
Citation: Bioelectromagnetics 10():51-64

Author: Hayashi,N, Isaki,K, Yokoi,Y
Year: 1992
Title: Analysis of 60-Hz magnetic fields near ground level in 187-kV switchyard of a 187/66-kV AC substation
Citation: IEEE Transactions on Power Delivery 7():237-244

Author: Hefeneider,S et al.
Year: 1994
Title: Joint HVAC Transmission EMF Environmental Study: Final report on experiment 3
Citation: Bonneville Power Administration, Portland, OR

Author: Heroux,P
Year: 1984
Title: 60 Hz electric and magnetic fields generated by a distribution network
Citation: Institut de Recherche d'Hydro-Quebec, Varennes, Quebec

Author: Heroux,P
Year: 1987
Title: 60-Hz electric and magnetic fields generated by a distribution network
Citation: Bioelectromagnetics 8():135-148

Author: Hietanen,M, Juuti,P, Juutilainen,J
Year: 1993
Title: Exposure of railway personnel to electromagnetic fields
Citation: European Bioelectromagnetics Assoc. (EBEA), 2nd Congress, 9-11 December, Bled, Slovenia, EBEA, EBEA, ?,, 14-15

Author: Hiles,ML, Olsen,RG, Holte,KC, Jensen,DR, Griffing,KL
Year: 1995
Title: Power frequency magnetic field management using a combination of active and passive shielding technology
Citation: Institute of Electrical and Electronics Engineers, Inc., IEEE, New York

Author: Hofmann,H, Preston,G
Year: 1994
Title: Reduction of stray currents and magnetic fields from single-phase power distribution systems
Citation: Institute of Electrical and Electronics Engineers, IEEE, New York

Author: Hogue,PS, Yost,MG, Camp,JE
Year: 1995
Title: Characterization of exposures to extremely low frequency magnetic fields in the office environment
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates Ltd., W/L Associates, Ltd., Frederick, MD, A-34, 38

Author: Israel,MS, Mahler,Y, Blau,D, Levinger,E
Year: 1995
Title: Nonionizing radiation around linear accelerators
Citation: Applied Occupational and Environmental Hygiene 10(9):788-792

Author: ITT Research Institute
Year: 1984
Title: Representative electromagnetic field intensities near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360
Citation: ITT Research Institute, Chicago, IL

Author: Juutilainen,J, Saali,K
Year: 1986
Title: Measurements of extremely low-frequency magnetic fields around video display terminals
Citation: Scandinavian Journal of Work, Environment and Health 12(6):609-613

Author: Karady,GG, Berisha,SH, Hobbs,RS, Demcko,JA
Year: 1993
Title: Comparison of magnetic fields generated by DC and AC electric vehicles
Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates, W/L Associates, Ltd., Frederick, MD, P-1, 26-27

Author: Karner,HC, Stamm,AR
Year: 1991
Title: Residential long-term magnetic field exposure
Citation: Institut fur Hochspannungstechnik, Technical University Braunschweig, Braunschweig, Federal Republic of Germany

Author: Katoh,K, Asano,Y, Juto,N, Tomizawa,N
Year: 1993
Title: Electric and magnetic fields found in the vicinity of CRTs and power lines (meeting abstract)
Citation: Health Physics 65(1):110

Author: Kaune,WT, Darby,SD, Gardner,SN, Hrubec,Z, Iriye,RN, Linet,MS
Year: 1994
Title: Development of a protocol for assessing time-weighted-average exposures of young children to power-frequency magnetic
Citation: Bioelectromagnetics 15():33-51

Author: Kaune,WT, Leland,PD, Geissinger,L
Year: 1995
Title: Scoping study of magnetic fields associated with the Seattle Metro electric trolley system
Citation: BEMS abstract book: Seventeenth Annual Meeting, The Bioelectromagnetics Society, The Bioelectromagnetics Society, Frederick, MD, 13-4, 66

Author: Kaune,WT, Niple,JC, Liu,MJ, Silva,JM
Year: 1992
Title: Small integrating meter for assessing long-term exposure to magnetic fields
Citation: Bioelectromagnetics 13():413-427

Author: Kaune,WT, Preece,AW, Grainger,P, Golding,J
Year: 1996
Title: Assessment of human exposure to magnetic fields produced by domestic appliances
Citation: Lockheed Martin Energy Systems, Inc., Oak Ridge, TN

Author: Kaune,WT, Stevens,RG, Callahan,NJ, Severson,RK, Thomas,DB
Year: 1987
Title: Residential magnetic and electric fields measured over 24-H periods
Citation: Health Research, Inc., Albany, NY

Author: Kaune,WT, Stevens,RG, Callahan,NJ, Severson,RK, Thomas,DB
Year: 1987
Title: Residential magnetic and electric fields
Citation: Bioelectromagnetics 8():315-335

Author: Kaune,WT, Zaffanella,LE
Year: 1992
Title: Assessment of children's long-term exposure to magnetic fields (The Enertech Study)
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Kavet,R, Silva,JM, Thornton,D
Year: 1992
Title: Magnetic field exposure assessment for adult residents of Maine who live near and far away from overhead transmission lines
Citation: Bioelectromagnetics 13():35-55

Author: Kavet,R, Silva,JM, Thornton,D
Year: 1992
Title: Magnetic field exposure assessment for adult residents of Maine who live near and far away from overhead transmission lines
Citation: Bioelectromagnetics 13():35-55

Author: Koontz,MD, Dietrich,FM
Year: 1994
Title: Variability and predictability of children's exposure to magnetic fields
Citation: Journal of Exposure Analysis and Environmental Epidemiology 4(3):287-307

Author: Koontz,MD, Mehegan,LL, Dietrich,FM, Nagda,NL
Year: 1992
Title: Assessment of children's long-term exposure to magnetic fields (The Geomet Study)
Citation: Electric Power Research Institute, Palo Alto, CA

Author: Korpinen,L, Partanen,J, Uusitalo,A
Year: 1993
Title: Influence of 50 Hz electric and magnetic fields on the human heart
Citation: Bioelectromagnetics 14():329-340

Author: Kromhout,H, Loomis,DP, Mihlan,GJ, Peipins,LA, Kleckner,RC, Iriye,R, Savitz,DA
Year: 1995
Title: Assessment and grouping of occupational magnetic field exposure in five electric utility companies
Citation: Scandinavian Journal of Work, Environment and Health 21(1):43-50

Author: Lamont,JW, Hillesland,GG, Mitchell,AJ
Year: 1990
Title: A composite exposure index for magnetic field exposure
Citation: Iowa State University, Ames, IA

Author: Lanera,D, Zapotosky,JE, Colby,JA
Year: 1995
Title: Water lines and their epidemiological relevance in differentiating rural from urban magnetic field exposure
Citation: BEMS abstract book: Seventeenth Annual Meeting, The Bioelectromagnetics Society, The Bioelectromagnetics Society, Frederick, MD, 13-3, 64-65

Author: Larsen,AI, Skotte,J
Year: 1991
Title: Can exposure to electromagnetic radiation in diathermy operators be estimated from interview data? A pilot study
Citation: American Journal of Industrial Medicine 19():51-57

Author: Lee Jr.,JM, Stormshak,F, Thompson,JM, Thinesen,P, Painter,LJ, Olenchek,EG, Hess,DL, Forbes,R, Foster,DL
Year: 1993
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Year: 1992

Title: Occupational exposure to electromagnetic fields in relation to leukemia and brain tumo A case-control study

Citation: Litohuset, Stockholm

Urban?:	yes	Rural?:	unk	PE measurements?:	yes
Preschoolers?:	no	Children?:	no	Area survey measurements?:	no
Adults?:	yes	Seniors?:	unk	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	850 cases, 1700 controls
Work-inside activity?:	yes	Work-outside activity?:	yes	Exposure characterized:	magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	yes
School-inside activity?:	no	School-outside activity?:	no	Job category?:	yes
School-inside characteristics?:	no	School-outside	no	Time period:	1983-1987 (cases), study performed from 1988-1992
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	Sweden
Other-inside characteristics?:	no	Other-outside	no		

Author: Floderus,B, Persson,T, Stenlund,C, Wennberg,A, Ost,A, Knave,B

Year: 1993

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Citation: Cancer Causes and Control 4():465-476

Urban?:	yes	Rural?:	yes	PE measurements?:	yes
Preschoolers?:	no	Children?:	no	Area survey measurements?:	no
Adults?:	yes	Seniors?:	yes	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	1015 measurements
Work-inside activity?:	no	Work-outside activity?:	no	Exposure characterized:	magnetic field
Work-inside characteristics?:	yes	Work-outside characteristics?:	yes	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	yes
School-inside characteristics?:	no	School-outside	no	Time period:	1983-1987
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	Sweden
Other-inside characteristics?:	no	Other-outside	no		

Author: Florig,HK

Year: 1986

Title: Population exposure to power-frequency fields. PhD. Dissertation 1986

Citation: Carnegie-Mellon University, Pittsburgh, PA

Urban?:	yes	Rural?:	no	PE measurements?:	no
Preschoolers?:	yes	Children?:	yes	Area survey measurements?:	yes
Adults?:	yes	Seniors?:	yes	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	yes
Home-inside characteristics?:	yes	Home-outside characteristics?:	yes	Sample size:	6 houses
Work-inside activity?:	no	Work-outside activity?:	no	Exposure characterized:	electric field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	no
School-inside characteristics?:	no	School-outside	no	Time period:	
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

Author: Florig,HK, Hoburg,JF

Year: 1990

Title: Power-frequency magnetic fields from electric blankets

Citation: Health Physics 58(4):493-502

Urban?:	yes	Rural?:	yes	PE measurements?:	no
Preschoolers?:	no	Children?:	yes	Area survey measurements?:	no
Adults?:	yes	Seniors?:	yes	Area longterm measurements?:	no
Home-inside activity?:	yes	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	results for 4 blankets provided
Work-inside activity?:	no	Work-outside activity?:	no	Exposure characterized:	magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	no
School-inside characteristics?:	no	School-outside	no	Time period:	
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

Author: Flynn,MR, West,S, Kaune,WT, Savitz,DA, Chen,C-C, Loomis,DP

Year: 1991

Title: Validation of expert judgment in assessing occupational exposure to magnetic fields in the utility industry

Citation: Applied Occupational and Environmental Hygiene 6(2):141-145

Urban?:	yes	Rural?:	no	PE measurements?:	yes
Preschoolers?:	no	Children?:	no	Area survey measurements?:	no
Adults?:	yes	Seniors?:	unk	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	134 workers
Work-inside activity?:	yes	Work-outside activity?:	yes	Exposure characterized:	magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	yes
School-inside activity?:	no	School-outside activity?:	no	Job category?:	yes
School-inside characteristics?:	no	School-outside	no	Time period:	
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

Author: Friedman,DR, Hatch,EE, Tarone,R, Kaune,WT, Kleinerman,RA, Wacholder,S, Boice Jr.,JD, Linet,MS

Year: 1996

Title: Childhood exposure to magnetic fields: Residential area measurements compared to personal dosimetry

Citation: Epidemiology 7(2):151-155

Urban?:	yes	Rural?:	unk	PE measurements?:	yes
Preschoolers?:	yes	Children?:	yes	Area survey measurements?:	no
Adults?:	no	Seniors?:	no	Area longterm measurements?:	yes
Home-inside activity?:	yes	Home-outside activity?:	yes	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	64 children
Work-inside activity?:	no	Work-outside activity?:	no	Exposure characterized:	magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	yes	School-outside activity?:	yes	Job category?:	no
School-inside characteristics?:	no	School-outside	no	Time period:	
Other-inside activity?:	yes	Other-outside activity?:	yes	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

Author: Fulcomer,PM

Year: 1985

Title: NBS ambient magnetic field meter for measurement and analysis of low-level power frequency magnetic fields in air

Citation: US Department of Energy, Washington, DC

Urban?:	yes	Rural?:	no	PE measurements?:	no
Preschoolers?:	yes	Children?:	yes	Area survey measurements?:	yes
Adults?:	yes	Seniors?:	yes	Area longterm measurements?:	no
Home-inside activity?:	yes	Home-outside activity?:	no	Source measurements?:	yes
Home-inside characteristics?:	yes	Home-outside characteristics?:	no	Sample size:	3 sites (laboratory, office, home)
Work-inside activity?:	yes	Work-outside activity?:	no	Exposure characterized:	magnetic field
Work-inside characteristics?:	yes	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	no
School-inside characteristics?:	no	School-outside	no	Time period:	
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

Author: Fulton,JP, Cobb,S, Preble,L, Leone,L, Forman,E

Year: 1980

Title: Electrical wiring configurations and childhood leukemia in Rhode Island

Citation: American Journal of Epidemiology 1980():292-296

Urban?:	yes	Rural?:	unk	PE measurements?:	no
Preschoolers?:	yes	Children?:	yes	Area survey measurements?:	no
Adults?:	yes	Seniors?:	no	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	yes	Sample size:	119 cases, 240 controls
Work-inside activity?:	no	Work-outside activity?:	no	Exposure characterized:	none
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	no
School-inside characteristics?:	no	School-outside	no	Time period:	1964-1978 (year of leukemia onset)
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	U.S., Rhode Island
Other-inside characteristics?:	no	Other-outside	no		

Author: Gamberale,F, Anshelm Olson,B, Eneroth,P, Lindh,T, Wennberg,A

Year: 1989

Title: Acute effects of ELF electromagnetic fields: a field study of linesmen working with 400 kV power lines

Citation: British Journal of Industrial Medicine 46(10):729-737

Urban?:	yes	Rural?:	yes	PE measurements?:	yes
Preschoolers?:	no	Children?:	no	Area survey measurements?:	no
Adults?:	yes	Seniors?:	no	Area longterm measurements?:	no
Home-inside activity?:	no	Home-outside activity?:	no	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	26 line workers
Work-inside activity?:	no	Work-outside activity?:	yes	Exposure characterized:	electric field, magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	yes	Industry?:	yes
School-inside activity?:	no	School-outside activity?:	no	Job category?:	yes
School-inside characteristics?:	no	School-outside	no	Time period:	August-October 1986
Other-inside activity?:	no	Other-outside activity?:	no	Geographic location:	Sweden
Other-inside characteristics?:	no	Other-outside	no		

Author: Gauvin,D, Levallois,P, Gingras,S

Year: 1993

Title: EMF exposure assessment for office employees: a pilot study

Citation: Project abstracts: The annual review of research on biological effects of electric and magnetic fields from the generation, delivery & use of electricity, W/L Associates, W/L Associates, Ltd., Frederick, MD, P-28, 49-50

Urban?:	yes	Rural?:	no	PE measurements?:	yes
Preschoolers?:	no	Children?:	no	Area survey measurements?:	no
Adults?:	yes	Seniors?:	no	Area longterm measurements?:	no
Home-inside activity?:	yes	Home-outside activity?:	yes	Source measurements?:	no
Home-inside characteristics?:	no	Home-outside characteristics?:	no	Sample size:	11 subjects
Work-inside activity?:	yes	Work-outside activity?:	no	Exposure characterized:	electric field, magnetic field
Work-inside characteristics?:	no	Work-outside characteristics?:	no	Industry?:	no
School-inside activity?:	no	School-outside activity?:	no	Job category?:	yes
School-inside characteristics?:	no	School-outside	no	Time period:	1993
Other-inside activity?:	yes	Other-outside activity?:	yes	Geographic location:	
Other-inside characteristics?:	no	Other-outside	no		

APPENDIX B

PILOT STUDY FORMS

Table B-1
List of Forms

Type of Form	Retrospective Diary	Concurrent Diary and Supplements
Subject Instructions	X	X
Meter Location Log	Subject	Subject
Concurrent Diary		Subject
Diary Supplement: Activities		Interviewer
Diary Supplement: Sources		Interviewer
Retrospective Diary	Interviewer	
Post-Diary Interview	Interviewer	Interviewer
Source Bookmarks	Interviewer	Interviewer
Follow-up: Sources	Interviewer	Interviewer
Interviewer Observations	Interviewer	Interviewer

Key:

Subject = Form is completed by the subject.
Interviewer = Form is completed by the interviewer, usually during the subject interview.
X = Form is only informational.

SUBJECT INSTRUCTIONS

INSTRUCTIONS FOR WEARING THE METER

The EMDEX meter is worn around the waist inside the blue pouch. Try to wear it **AT ALL TIMES** during the 24-hour monitoring period **EXCEPT THE FOLLOWING TIMES**:

DO NOT WEAR THE METER

if it is likely to be damaged, for example when bathing or during vigorous exercise,

if wearing it would restrict your ability to move around, or

when you go to sleep.

IF YOU HAVE TO TAKE THE METER OFF

place it in a safe place nearby and **MAKE AN ENTRY IN THE LOG**.

2. Make an entry in the log whenever you **PUT THE METER ON** or **TAKE THE METER OFF.**

3. If you have any questions please contact XYZ at 1-aaa-bbb-cccc

Call collect if not a local call.

METER LOCATION LOG

Name: ____________________________ Assigned ID #: ________________

LOG FOR RECORDING METER LOCATION

Date	Estimated Time	If meter worn, check "meter put on" If not worn, choose appropriate column and indicate where meter was placed			
		Meter Worn	Meter Not Worn Removed for **Sleep**	Meter Not Worn Removed for **Vigorous Activity**	Meter Not Worn **Other**
____/____/ 98 mo. day	____:____ am pm	☐ Meter put on	Meter placed ☐ .... nearby ☐ .... other specify:	Meter placed ☐ .... nearby ☐ .... other specify:	Reason not Worn: ____________ Meter placed ☐ .... nearby ☐ .... other specify:
____/____/ 98 mo. day	____:____ am pm	☐ Meter put on	Meter placed ☐ .... nearby ☐ .... other specify:	Meter placed ☐ .... nearby ☐ .... other specify:	Reason not Worn: ____________ Meter placed ☐ .... nearby ☐ .... other specify:

Name and ID# are repeated on subsequent pages along with additional log entries. That material has been deleted in the interest of brevity.

CONCURRENT DIARY

ID#:________

A RECORD OF YOUR ACTIVITIES ON THE DIARY DAY

First wore the meter:

Date: _____/_____/98 Day of week : _________ Time : ____________ am
month day pm

A. Activity #1: What were you doing then? (Your own brief description or words from Activity List)

B. Where were you when you did that?

Home Kitchen.....	1	Home Other	2	Workplace	3	School	4
Travel	5	Other Place	6	[SPECIFY: ____________________]			

C. Were you indoors or outdoors?

Indoors	1	Outdoors	2	In and out	3
Other	4	[SPECIFY: ________________________________]			

D. Did you use any corded electrical appliances or equipment while you were doing this activity?

No 1

Yes .... 2 IF YES, WRITE DOWN THE KINDS OF APPLIANCES OR EQUIPMENT BELOW

E. What time did you finish that activity and turn to something else? __________ am pm

The ID# and A through E are repeated on subsequent pages. That material has been deleted in the interest of brevity.

When did you stop wearing the meter (not counting the times you took it off to sleep or bathe and then put it on again)?

Date: _____/_____/98 Day of week : _________ Time : ____________ am
month day pm

DIARY SUPPLEMENT: ACTIVITIES

ID#:____________

Interviewer-Administered Diary Supplement: Activity Reports

Activity #: _______

Travel: No ....1 [SKIP]
Yes ....2 | Part of school ...... 1 | Electric train .... 1 | Transmission lines near 1
Part of work ..... 2 | Other travel ....2 | No transmission lines 2
Neither .... 3 | Don't know 3

Indoor location: No .... 1 [SKIP]
Yes 2
Single family residence 1
Multiple family unit 2
Grocery store 3
Other commercial bldg...... 4
Industrial bldg. 5
Other .... 6 [SPECIFY: ____________________]

General location: Urban...... 1 Suburban..... 2 Rural..... 3 Other..... 4 [SPECIFY:____________________]

Activity #: _______

Travel: No ....1 [SKIP]
Yes ....2 | Part of school ...... 1 | Electric train .... 1 | Transmission lines near 1
Part of work ..... 2 | Other travel ....2 | No transmission lines 2
Neither .... 3 | Don't know 3

Indoor location: No .... 1 [SKIP]
Yes 2
Single family residence 1
Multiple family unit 2
Grocery store 3
Other commercial bldg...... 4
Industrial bldg. 5
Other .... 6 [SPECIFY: ____________________]

General location: Urban...... 1 Suburban..... 2 Rural..... 3 Other..... 4 [SPECIFY:____________________]

This page is repeated as needed.

DIARY SUPPLEMENT: SOURCES

ID#:______________

Interviewer-Administered Diary Supplement: EMF Source Use Reports

[RECORD ALL APP/EQP BEFORE ASKING TIMES]

ACTIVITY #: __________

[APP/EQP] ____________________

____

(Ask if necessary) Corded? Yes No

About how many minutes did you use [APPL/EQUIP]?

Less than 1 minute 1

1 min to less than 5 mins 2

5 to less than 10 mins 3

10 to less than 15 mins 4

15 mins or more 5

[IF CODE 5, ASK] About how long was that?

_________ hrs ________ mins

[APP/EQP] ____________________

____

(Ask if necessary) Corded? Yes No

Less than 1 minute 1

1 min to less than 5 mins 2

5 to less than 10 mins 3

10 to less than 15 mins 4

15 mins or more 5

[IF CODE 5, ASK] About how long was that?

_________ hrs ________ mins

This page is repeated as needed.

RETROSPECTIVE DIARY

ID#:_______________

First, I'd like to be sure of the period when you wore the meter.

When did you begin wearing the meter?

Date: ______/______/98 Day of week : _________ Time : _____________ am
month day pm

When did you stop wearing the meter (not counting the times you took it off to sleep or bathe and then put it on again)?

Date: ______/______/98 Day of week : _________ Time : _____________ am
month day pm

Now I'd like to ask you how you spent your time when you were wearing the meter, that is from (BEGIN DATE/TIME) until (END DATE/TIME). I'd like to start when you first put on the meter and go through the whole period while you wore it. For each thing you did during that period, I'll be asking you to tell me

- What you were doing
- Where you were and whether you were inside or outside
- If you used any electrical appliances or equipment
- What time you turned to something else

Please tell me about everything you did while you wore the meter in the same order that it happened. There shouldn't be any gaps in time between activities.

Let's start with [BEGIN DATE/TIME] when you first put on the meter.

ID#:______________

ACTIVITY # ________

A. [FIRST ACTIVITY:] What were you doing then? [NEXT ACTIVITY:] What did you do next? [RECORD ACTIVITY VERBATIM]

[ASK FOLLOWING QUESTIONS IF NECESSARY. ALWAYS CODE TYPE OF PLACE, INDOORS/OUTDOORS AND GENERAL LOCATION EVEN IF ANSWERS ARE OBVIOUS FROM RESPONSE TO QUESTION A]

B1. Where were you when you did [that/ACT]?

Home Kitchen..... 1

Home Other 2

Workplace 3

School 4

Travel 5

B1a. Was travel a part of school activities during normal school hours or work activities during normal work hours?

Part of school activities 1

Part of work activities 2

Neither work nor school 3

[IF NECESSARY ASK] B1b. Did you travel by electric train or trolley or some other way?

Electric train/trolley ... 1

Other travel 2

Other .... 6 [SPECIFY:] ______________________

____

ID#:______________

ACTIVITY # ________

AND ASK: B1c.Are there any transmission towers near that place?

Yes, transmission towers near 1

No, no transmission towers near ...2

Don't know 3

[IF NECESSARY ASK] Were you indoors or outdoors?

Indoors 1

[IF OTHER PLACE, B1=CODE 5, ASK] B2a. What kind of indoor location was it? [READ LIST]

Single family residence 1

Multiple family unit 2

Grocery store 3

Other commercial bldg. 4

Industrial building............. 5

Other [SPECIFY: ________

______________________] 6

Outdoors 2

In and out 3

Other .... 4 (SPECIFY: __________________

__________________________)

ID#:______________

ACTIVITY # ________

B3. [IF NECESSARY ASK] Is that location in a city, a suburb, in a rural area, or in a more remote place?

Urban 1

Suburban 2

Rural 3

Other .... 4 (SPECIFY: ____________________

____________________)

C. Did you use any electrical appliances or equipment while you were doing [ACT]?

No .... 1 [GO TO QUESTION D]

Yes .... 2 [SKIP TO NEXT PAGE]

D. What time did you finish [ACT] and turn to something else? ___________ am pm

ID#:______________

ACTIVITY # ________

[IF CODE 2, QUESTION C, ASK:] C1.What types of appliances [and/or equipment] did you use?

[RECORD ALL APP/EQP BEFORE ASKING C2]	C2. About how many minutes did you use [APPL/EQUIP]?	
[FIRST APP/EQP] ______________	Less than 1 minute	1
______________________________	1 to less than 5 mins	2
(Ask if necessary) Corded? Yes No	5 to less than 10 mins	3
	10 to less than 15 mins	4
	15 mins or more	5
	[IF CODE 5, ASK] About how long was that?	
	________ hrs ________ mins	
[SECOND APP/EQP] ______________	Less than 1 minute	1
______________________________	1 to less than 5 mins	2
(Ask if necessary) Corded? Yes No	5 to less than 10 mins	3
	10 to less than 15 mins	4
	15 mins or more	5
	[IF CODE 5, ASK] About how long was that?	
	________ hrs ________ mins	

[ASK QUESTION D AFTER COMPLETING C1 AND C2 FOR ALL APP/EQP. IF NECESSARY, SKIP TO CONTINUATION PAGE.]

Check if Continuation Page Used _______

D. What time did you finish [ACT] and turn to something else? ___________ am pm

ID#:_______________

ACTIVITY # ________

[RECORD ALL APP/EQP BEFORE ASKING C2]

C2. About how many minutes did you use [APPL/EQUIP]?

[NEXT APP/EQP] _______________

____

(Ask if necessary) Corded? Yes No

Less than 1 minute	1
1 to less than 5 mins	2
5 to less than 10 mins	3
10 to less than 15 mins	4
15 mins or more	5

[IF CODE 5, ASK] About how long was that?

_________ hrs ________ mins

[NEXT APP/EQP] _______________

____

(Ask if necessary) Corded? Yes No

Less than 1 minute	1
1 to less than 5 mins	2
5 to less than 10 mins	3
10 to less than 15 mins	4
15 mins or more	5

[IF CODE 5, ASK] About how long was that?

_________ hrs ________ mins

[ASK QUESTION D AFTER COMPLETING C1 AND C2 FOR ALL APP/EQP. IF NECESSARY, SKIP TO NEXT CONTINUATION PAGE.]

Check if Continuation Page Used _______

D. What time did you finish [ACT] and turn to something else? _____________ am pm

This page is repeated as needed.
ID and ACTIVITY sets (pages two through six) are repeated as needed.

POST-DIARY INTERVIEW

ID#:______________

SECTION A: ABOUT THE PARTICIPANT

[ASK ALL PARTICIPANTS]

Now I'd like to ask you a few questions about yourself.

1. First of all, how old are you today? [RECORD AGE IN YEARS] ______________

2. And now a few questions about your work history. Are you employed full-time or part-time, are you unemployed, retired, a homemaker, a student, or what?

Employed full-time (35+ hours)	1	
Employed part-time	2	
Unemployed	3	[SKIP TO SECTION B]
Retired	4	[SKIP TO SECTION B]
Homemaker	5	[SKIP TO SECTION B]
Student	6	[SKIP TO SECTION B]
Other (SPECIFY:________________________)	9	[SKIP TO SECTION B]

3. Thinking of the job you have, what kind of business or industry do you work for? [IF NECESSARY: What do they do or make there?]

4. What is your job title? And exactly what do you do there? What are your main duties.?

CHECK WORK BOOKMARK

5. DID PARTICIPANT SPENT TIME AT WORK ON THE DIARY DAY?

YES 1

NO .... 2 [SKIP TO SECTION B]

6.You said you spent some time at work while you wore the meter. Just to be sure we ask about all the electrical devices you might have used at work, please look at this list [HAND PARTICIPANT THE WORK BOOKMARK WITH STANDARD SOURCE LIST FOR ALL EMPLOYED PERSONS] and tell me if you used any of these appliances or equipment while you wore the meter at work. [READ THROUGH THE STANDARD SOURCE LIST. COMPLETE **(FOLLOW-UP: SOURCES)** FOR ANY ELIGIBLE DEVICE THAT WAS NOT REPORTED IN THE DIARY]

7. IS PARTICIPANT'S JOB TITLE IS ON A SPECIAL SOURCE PROBE LIST?

YES 1

NO .... 2 [SKIP TO SECTION B]

8. How about this list of appliances or equipment. **(DELETION)** Did you use any of these appliances or equipment while you wore the meter at work? [READ THROUGH THE SPECIAL SOURCE LIST. COMPLETE **(FOLLOW-UP: SOURCES)** FOR ANY ELIGIBLE DEVICE THAT WAS NOT REPORTED IN THE DIARY]

ID#:_____________

SECTION B: ABOUT THE HOME ENVIRONMENT

CHECK HOME BOOKMARK

1. DID PARTICIPANT SPEND TIME AT HOME ON THE DIARY DAY?

YES 1

NO .... 2 [SKIP TO SECTION C]

Now I'd like to ask you a few questions about your residence.

1. First of all, when was the [house/building] constructed? Was it before 1965 or was it 1965 or after?

Before 1965 1

1965 or after 2

Don't know .... 9 [INTERVIEWER EST.:

Before 1965 1

1965 or after .... 2]

2. I'd like to ask you to estimate the size of your [house/apartment/other type of residence] in number of square feet. Do you think it is less than 1800 square feet or is it 1800 square feet or greater?

Less than 1800 square feet 1

1800 square feet or greater 2

Don't know .... 9 [INTERVIEWER EST.:

< 1800 sq.ft. 1

>= 1800 sq.ft. .... 2]

3. Do you have electric ceiling heat in your [house/apartment/other type of residence]?

Yes, we have.................. 1

No, we don't have.......... 2

Don't know.................. 3 [PROBE: How do you heat your house?]

ID#:_____________

4. Do you have two- or three-pronged electrical outlets in your [house/apartment/other type of residence]?

Two-pronged outlets only 1

Three-pronged outlets only 2

Both two- & three-pronged outlets 3

Don't know .... 9 [INSPECT: 1 2 3]

5. [ASK IF NECESSARY] Is your water supplied by a water system, a shared well, or by a private well that serves only your residence?

A water system or shared well 1

A private well 2

Don't know .... 3 [PROBE: Do you pay a water bill?]

6. Just to be sure we ask about all the electrical devices you might have used at home, please look at this list [HAND PARTICIPANT THE HOME BOOKMARK] and tell me about any appliances or equipment you used, including things used for hobbies, while you wore the meter at home. [READ THROUGH THE LIST. COMPLETE **(FOLLOW-UP: SOURCES)** FOR ANY ELIGIBLE DEVICE THAT WAS NOT REPORTED IN THE DIARY]

SECTION C: ABOUT THE SCHOOL ENVIRONMENT

CHECK SCHOOL BOOKMARK

1. DID THE PARTICIPANT SPENT TIME IN SCHOOL AS STUDENT ON THE DIARY DAY?

YES 1

NO .... 2 [SKIP TO SECTION D]

You said that you spent some time at school while you wore the meter. I'd like to ask you a few questions about the school.

1. First of all, does the school you attend have a regular campus, is it located at a residential site, or is it in a commercial building?

A regular campus 1

A residential site 2

A commercial building 3

Don't know or not sure .... 9 [PROBE AND CODE AS APPROPRIATE:
Where are the classes held?
What types of buildings?
In a business district?]

2. Is the place where you go to attend class near any overhead power lines you can see?

Overhead lines visible 1

None visible 2

Don't know 9

3.. Are there any transmission towers near the school?

Yes, transmission towers near 1

No, no transmission towers near 2

Don't know 3

4. Just to be sure we ask about all the electrical devices you might have used at school, please look at this list [HAND PARTICIPANT THE SCHOOL BOOKMARK] and tell me about any appliances or equipment you used while you wore the meter at school. [READ THROUGH THE LIST. COMPLETE **(FOLLOW-UP: SOURCES)** FOR ANY ELIGIBLE DEVICE THAT WAS NOT REPORTED IN THE DIARY]

ID#:_____________

SECTION D: SOURCE USE IN OTHER ENVIRONMENTS

CHECK OTHER BOOKMARK

1. DID THE PARTICIPANT SPENT TIME IN OTHER ENVIRONMENTS ON DIARY DAY?

YES 1

NO .... 2 [SKIP TO END]

You said that you spent some time away from home [but not at school or work] while you wore the meter. Just to be sure we ask about all the electrical devices you might have used during those times, please look at this list [HAND PARTICIPANT THE OTHER BOOKMARK] and tell me about any appliances or equipment you used while you wore the meter. [READ THROUGH THE LIST. COMPLETE **(FOLLOW-UP: SOURCES)** FOR ANY ELIGIBLE DEVICE THAT WAS NOT REPORTED IN THE DIARY]

Bookmark

ID#:______________

□ **HOME**

Yard
- □ blower
- □ clipper

Kitchen
- □ can opener
- □ coffee grinder
- □ food processor
- □ fry pan broiler
- □ ice cream maker
- □ knife sharpener
- □ microwave oven
- □ mixer, hand
- □ mixer, tabletop
- □ range
- □ meat slicer

Household
- □ air cleaner
- □ electric broom
- □ fluorescent lamp
- □ heater
- □ clothes iron
- □ sewing machine
- □ vacuum

Personal care
- □ electric blanket
- □ hair dryer, gun type
- □ hair dryer, hood type
- □ heating pad
- □ shaver with power cord
- □ hair clipper with power cord
- □ shaver with battery
- □ bathtub spa

Entertainment or office
- □ copy machine
- □ fan
- □ fluorescent light
- □ pencil sharpener
- □ projector, overhead slide
- □ typewriter, electric
- □ uninteruptable power supply
- □ video display terminal
- □ aquarium pump

Tools
- □ drill bit sharpener
- □ drill press
- □ drill, portable
- □ engraver
- □ grinder
- □ painter, airless
- □ hand router
- □ hand sander
- □ circular saw
- □ portable jig saw
- □ reciprocating saw
- □ table saw
- □ soldering gun or iron

Equipment
- □ air compressor
- □ arc welder
- □ welder power supply

□ **SCHOOL**

Classroom
- □ aquarium pump
- □ electric fan
- □ fluorescent lamp
- □ heater
- □ electric pencil sharpener
- □ projector, overhead slide
- □ typewriter, electric
- □ video display terminal

Home economics class
- □ microwave oven
- □ mixer, electric hand
- □ mixer, tabletop
- □ range
- □ iron, clothes
- □ sewing machine

Other areas
- □ hair dryer, gun type
- □ vending machine

Office
- □ copy machine
- □ fluorescent light
- □ uninteruptable power supply

Shop classroom
- □ drill press
- □ drill, portable
- □ engraver
- □ grinder
- □ painter, airless
- □ hand router
- □ hand sander
- □ circular saw
- □ portable jig saw
- □ reciprocating saw
- □ table saw
- □ soldering gun or iron
- □ air compressor
- □ arc welder
- □ welder power supply

□ **ALL WORK ENVIRONMENTS**

- □ fluorescent light
- □ electric pencil sharpener
- □ arc welder
- □ electric hand drill
- □ electric hand saw
- □ electric hand grinder
- □ electric hand sander

□ **OTHER ENVIRONMENTS**

Entertainment or office
- □ projector, overhead slide
- □ aquarium pump
- □ copy machine
- □ electric fan
- □ fluorescent light
- □ pencil sharpener
- □ typewriter, electric
- □ uninteruptable power supply
- □ video display terminal

Personal care
- □ clothes iron
- □ hair dryer, gun type
- □ hair dryer, hood type
- □ heating pad
- □ shaver with power cord
- □ hair clipper with power cord

Food preparation
- □ food processor
- □ microwave oven
- □ mixer, electric hand
- □ mixer, tabletop
- □ electric range

Heating or cooling
- □ electric fan
- □ electric heater
- □ fluorescent light

Miscellaneous
- □ vending machine

Tools/hobby equipment
- □ sewing machine
- □ drill press
- □ drill, portable
- □ engraver
- □ grinder
- □ painter, airless
- □ hand router
- □ hand sander
- □ circular saw
- □ portable jig saw
- □ reciprocating saw
- □ table saw
- □ soldering gun or iron
- □ air compressor
- □ arc welder
- □ welder power supply

FOLLOW-UP: SOURCES

ID#:________________

Supplementary EMF Source Use Report

THIS FORM SHOULD BE USED TO RECORD SOURCE USE THAT WAS NOT REPORTED IN THE RETROSPECTIVE DIARY

[RECORD ALL ADDITIONAL APP/EQP BEFORE ASKING TIMES]	About how many minutes did you use [APPL/EQUIP]?	
[APP/EQP] ____________________	Less than 1 minute	1
____________________	1 min to less than 5 mins	2
(Ask if necessary) Corded? Yes No	5 to less than 10 mins	3
OCCURRED DURING	10 to less than 15 mins	4
ACTIVITY # ____________	15 mins or more	5
AT APPROXIMATELY		
________________ am pm	[IF CODE 5, ASK] About how long was that?	
	________ hrs ________ mins	

Appliance/equipment use information is repeated.
That material has been deleted in the interest of brevity.

This page is repeated as needed.

INTERVIEWER OBSERVATIONS

ID#:_______________

INTERVIEWER OBSERVATIONS

1. Gender of participant

Male 1

Female 2

IF INTERVIEW IS NOT DONE AT PARTICIPANT'S RESIDENCE, ASK Q2 THROUGH Q4.

2. Type of residence [Is your residence a .....]

Single family detached house 1

Duplex or other multiple family unit 2

Apartment in building with 4 or more units 3

Other [SPECIFY: ________________________] 4

3. Overhead line near residence [Can you see any overhead power lines near your residence?]

Overhead line visible 1

None visible 2

4. Transmission towers within ________ distance from residence [Are there any transmission towers near your residence?]

Present 1

None visible at that distance 2

5. Type of area where residence is located [Do you live in a town or city, suburban location, rural area, or some other kind of place?]

Town or city 1

Suburban location 2

Rural Area 3

Other [SPECIFY: ________________________] 4

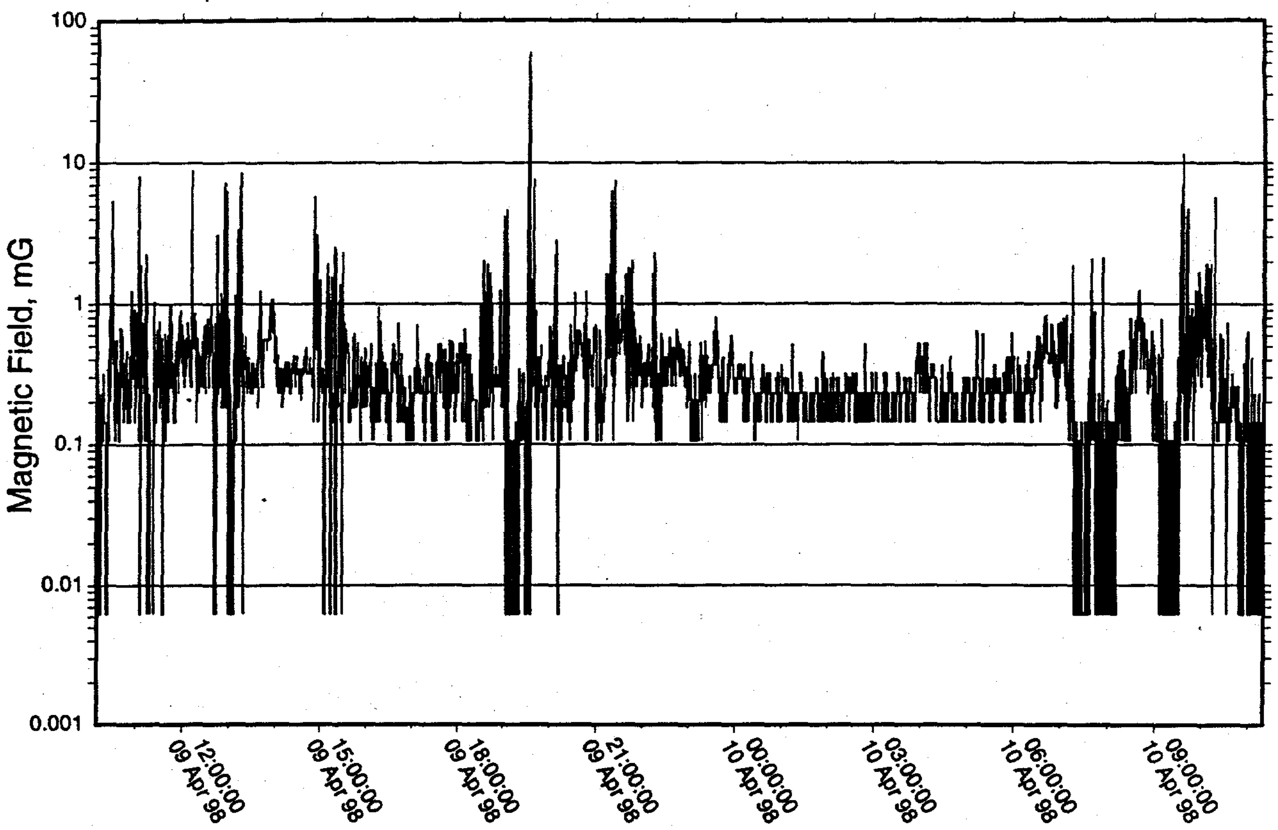
APPENDIX C

PILOT STUDY: MAGNETIC FIELD PLOTS AND SUBJECT DIARY ENTRIES

Magnetic Field Measurements: Subject No. 1

RAPID7

Unshaded periods include worn measurements

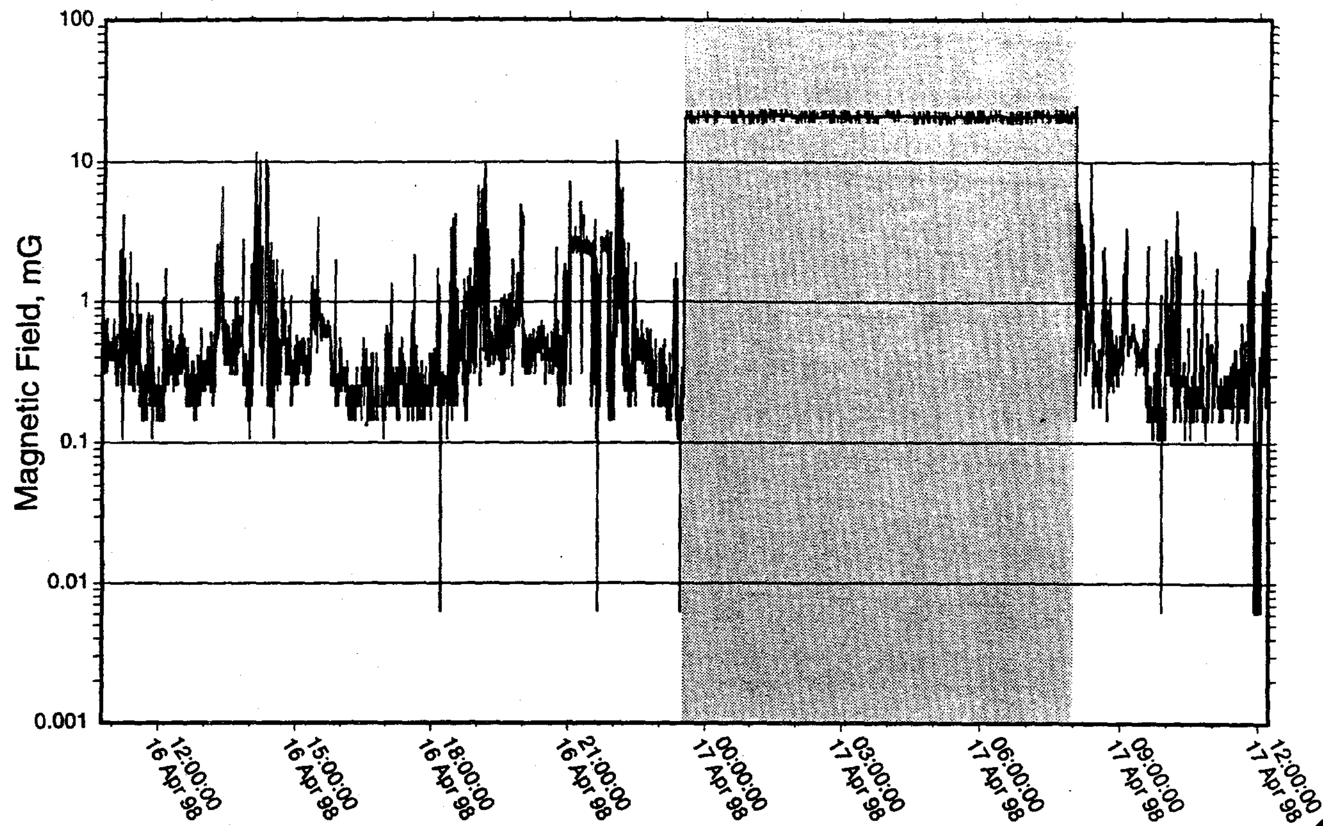


Start date/time			*Location*		*Act*
Thu	04/09	10:11:14	Home	01	21
Thu	04/09	10:35:04	Home	01	244
Thu	04/09	12:35:04	Travel	30	46
Thu	04/09	13:10:04	Other	26	192
Thu	04/09	15:00:04	Travel	30	197
Thu	04/09	15:10:04	Other	05	4
Thu	04/09	15:20:04	Travel	30	196
Thu	04/09	15:30:04	Home	01	125
Thu	04/09	18:10:04	Home	01	79
Thu	04/09	18:30:04	Travel	30	193
Thu	04/09	18:45:04	Other	22	8
Thu	04/09	18:55:04	Other	16	7
Thu	04/09	19:30:04	Travel	30	198
Thu	04/09	19:45:04	Other	27	169
Thu	04/09	20:00:04	Travel	30	196
Thu	04/09	20:10:04	Home	01	219
Thu	04/09	20:30:04	Home	01	134
Thu	04/09	21:15:04	Home	01	120
Thu	04/09	21:30:04	Home	01	109
Thu	04/09	23:00:04	Home	01	233
Fri	04/10	06:15:04	Home	01	104
Fri	04/10	07:17:04	Home	01	191
Fri	04/10	07:36:04	Home	01	130
Fri	04/10	08:00:04	Home	01	189
Fri	04/10	09:00:04	Home	01	99
Fri	04/10	11:19:59	End of data		

Magnetic Field Measurements: Subject No. 2

RAPID7

Unshaded periods include worn measurements

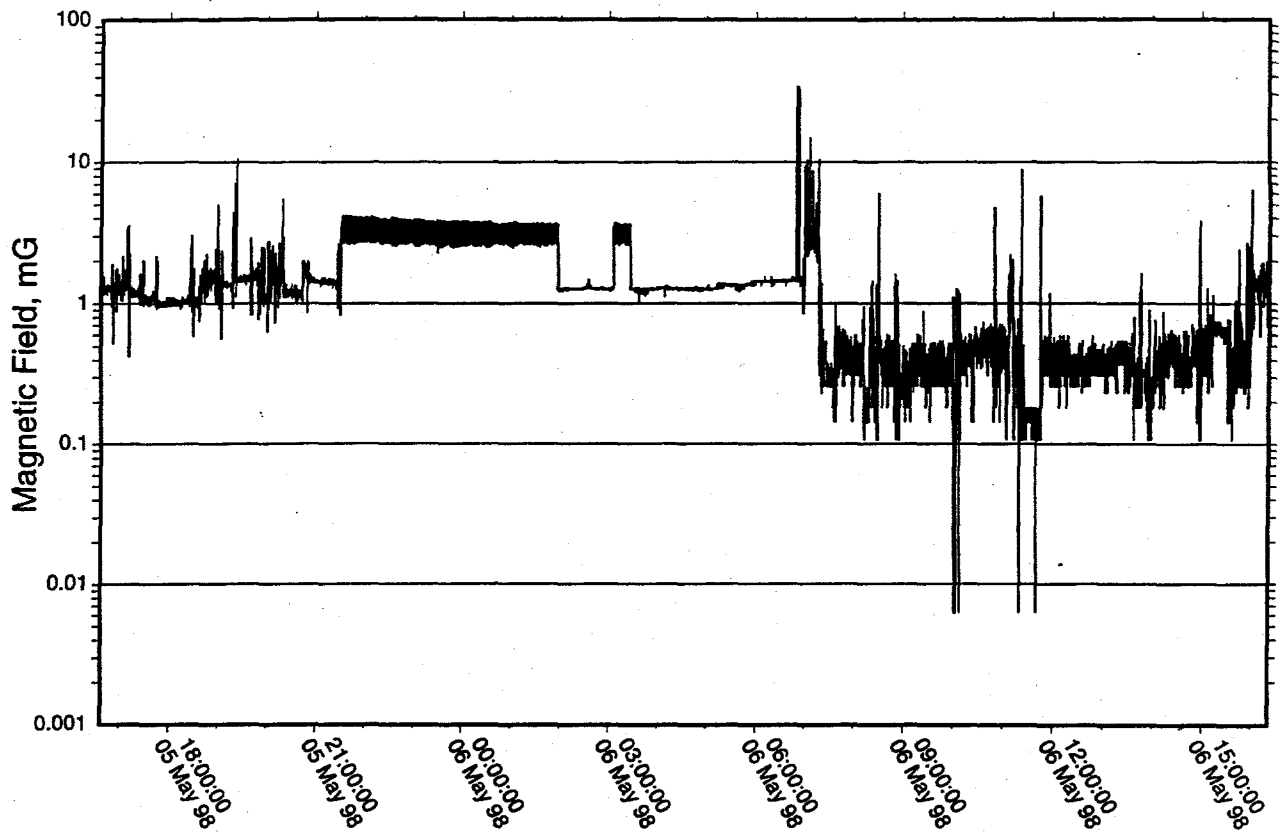


Start date/time	*Location*		*Act*
Thu 04/16 10:47:14	**Home**	**02**	**33**
Thu 04/16 11:09:04	**Home**	**03**	**127**
Thu 04/16 11:15:04	**Home**	**03**	**243**
Thu 04/16 13:20:04	**Home**	**02**	**121**
Thu 04/16 13:50:04	**Travel**	**30**	**58**
Thu 04/16 13:55:04	**Other**	**28**	**172**
Thu 04/16 14:25:04	**Travel**	**30**	**193**
Thu 04/16 14:30:04	**Home**	**03**	**109**
Thu 04/16 18:00:04	**Travel**	**30**	**195**
Thu 04/16 18:25:04	**Home**	**02**	**137**
Thu 04/16 19:15:04	**Home**	**02**	**32**
Thu 04/16 20:00:04	**Home**	**03**	**243**
Thu 04/16 20:45:04	**Travel**	**30**	**194**
Thu 04/16 22:10:04	**Home**	**03**	**243**
Thu 04/16 22:30:04	**Home**	**03**	**97**
Thu 04/16 23:10:04	**Home**	**03**	**76**
Thu 04/16 23:30:04	Excluded		232
Fri 04/17 08:00:04	**Home**	**02**	**88**
Fri 04/17 09:35:04	**Home**	**02**	**245**
Fri 04/17 09:50:04	**Home**	**03**	**234**
Fri 04/17 09:55:04	**Home**	**02**	**110**
Fri 04/17 10:05:04	**Travel**	**30**	**187**
Fri 04/17 10:12:04	**Other**	**17**	**205**
Fri 04/17 10:40:04	**Home**	**03**	**109**
Fri 04/17 11:45:04	**Travel**	**30**	**132**
Fri 04/17 11:50:04	**Other**	**21**	**112**
Fri 04/17 12:00:04	**Travel**	**30**	**153**
Fri 04/17 12:14:09	**End of data**		

Magnetic Field Measurements: Subject No. 3

RAPID7

Unshaded periods include worn measurements

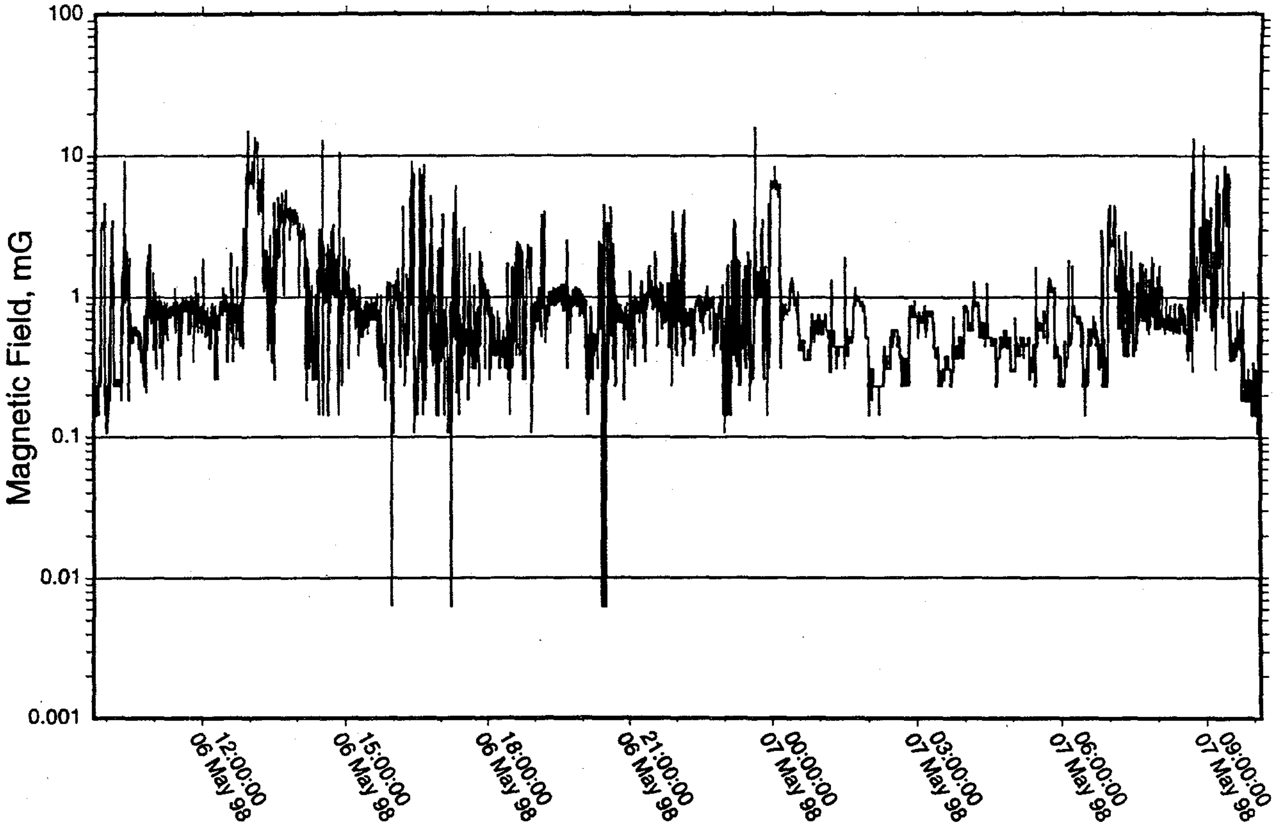


Start date/time	*Location*		*Act*
Tue 05/05 16:38:05	Home	03	19
Tue 05/05 17:15:00	Home	02	100
Tue 05/05 18:15:00	Home	03	185
Tue 05/05 19:00:00	Home	03	204
Tue 05/05 19:45:00	Home	03	142
Tue 05/05 20:00:00	Home	02	29
Tue 05/05 20:30:00	Home	03	71
Tue 05/05 21:00:00	Home	03	76
Tue 05/05 21:30:00	Home	03	174
Wed 05/06 06:00:00	Home	03	77
Wed 05/06 07:00:00	Travel	30	38
Wed 05/06 07:30:00	Work	31	11
Wed 05/06 15:30:00	Travel	30	40
Wed 05/06 16:00:00	Home	02	29
Wed 05/06 16:21:20	End of data		

Magnetic Field Measurements: Subject No. 4

RAPID7

Unshaded periods include worn measurements

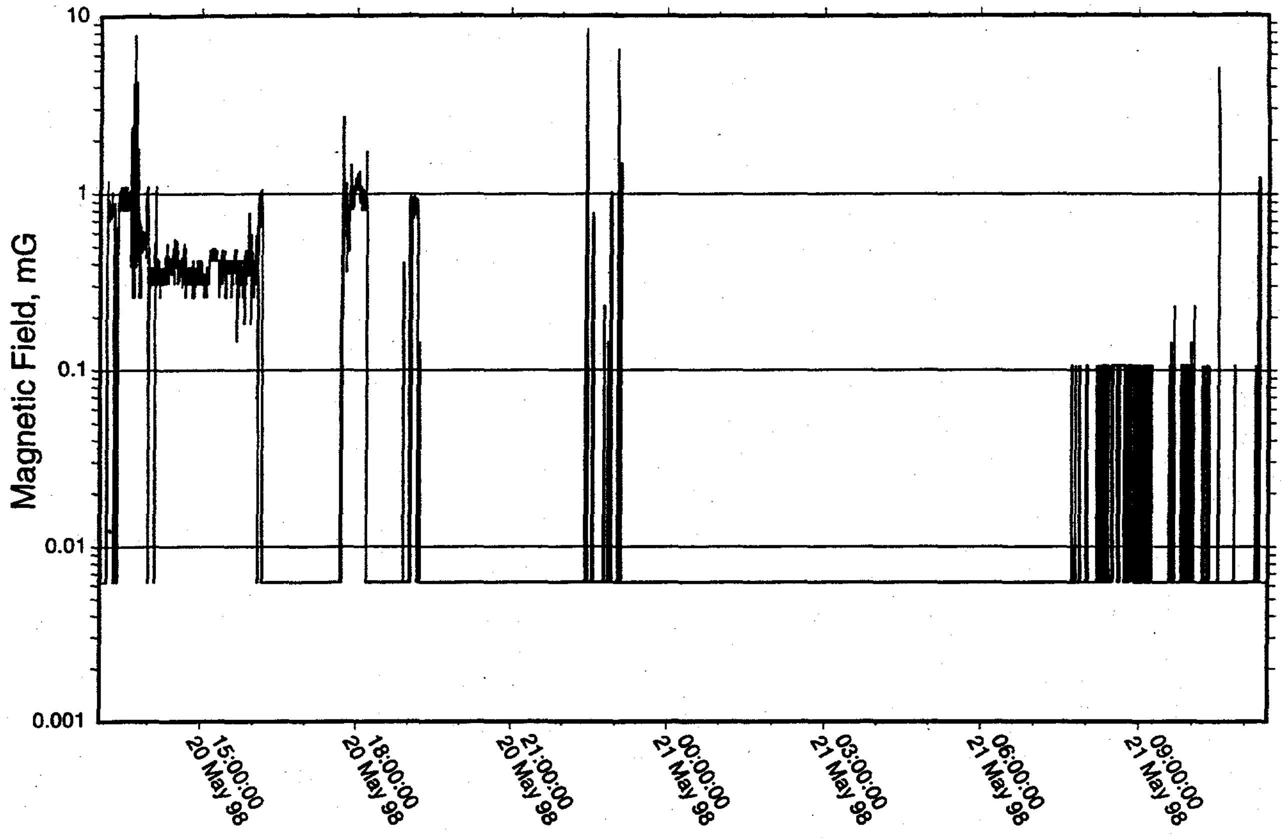


Start date/time	*Location*		*Act*
Wed 05/06 09:44:16	Other	11	207
Wed 05/06 09:50:01	Travel	30	37
Wed 05/06 10:00:01	Other	10	34
Wed 05/06 10:15:01	Travel	30	39
Wed 05/06 10:25:01	Home	03	151
Wed 05/06 10:45:01	Home	03	237
Wed 05/06 12:45:01	Travel	30	131
Wed 05/06 13:15:01	Travel	30	39
Wed 05/06 13:25:01	Home	02	117
Wed 05/06 13:50:01	Home	03	237
Wed 05/06 14:10:01	Home	03	151
Wed 05/06 14:40:01	Travel	30	115
Wed 05/06 14:50:01	Work	31	11
Wed 05/06 23:35:01	Travel	30	40
Wed 05/06 23:50:01	Home	03	76
Thu 05/07 00:00:01	Home	03	145
Thu 05/07 00:10:01	Home	03	76
Thu 05/07 00:45:01	Home	03	174
Thu 05/07 08:30:01	Home	03	81
Thu 05/07 08:40:01	Home	02	75
Thu 05/07 09:15:01	Home	03	22
Thu 05/07 10:08:21	End of data		

Magnetic Field Measurements: Subject No. 5

RAPID7

Unshaded periods include worn measurements

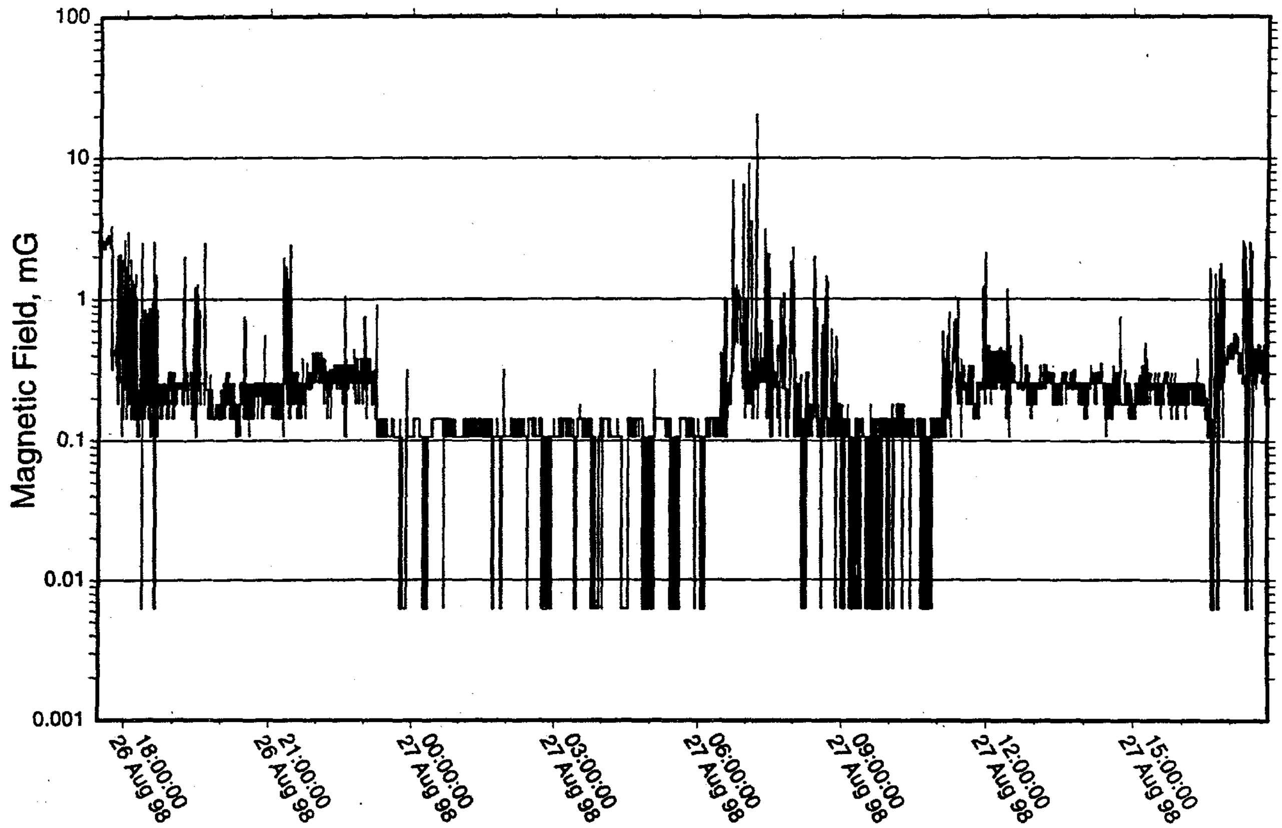


Start date/time	Location		Act
Wed 05/20 13:05:12	Other	09	184
Wed 05/20 13:50:02	Work	31	1
Wed 05/20 16:00:02	School	07	17
Wed 05/20 17:30:02	Travel	30	50
Wed 05/20 18:00:02	Other	11	133
Wed 05/20 18:45:02	Travel	30	39
Wed 05/20 19:00:02	Home	03	165
Wed 05/20 23:00:02	Home	03	174
Thu 05/21 07:00:02	Home	03	129
Thu 05/21 11:25:32	End of data		

Magnetic Field Measurements: Subject No. 6

RAPID7

Unshaded periods include worn measurements

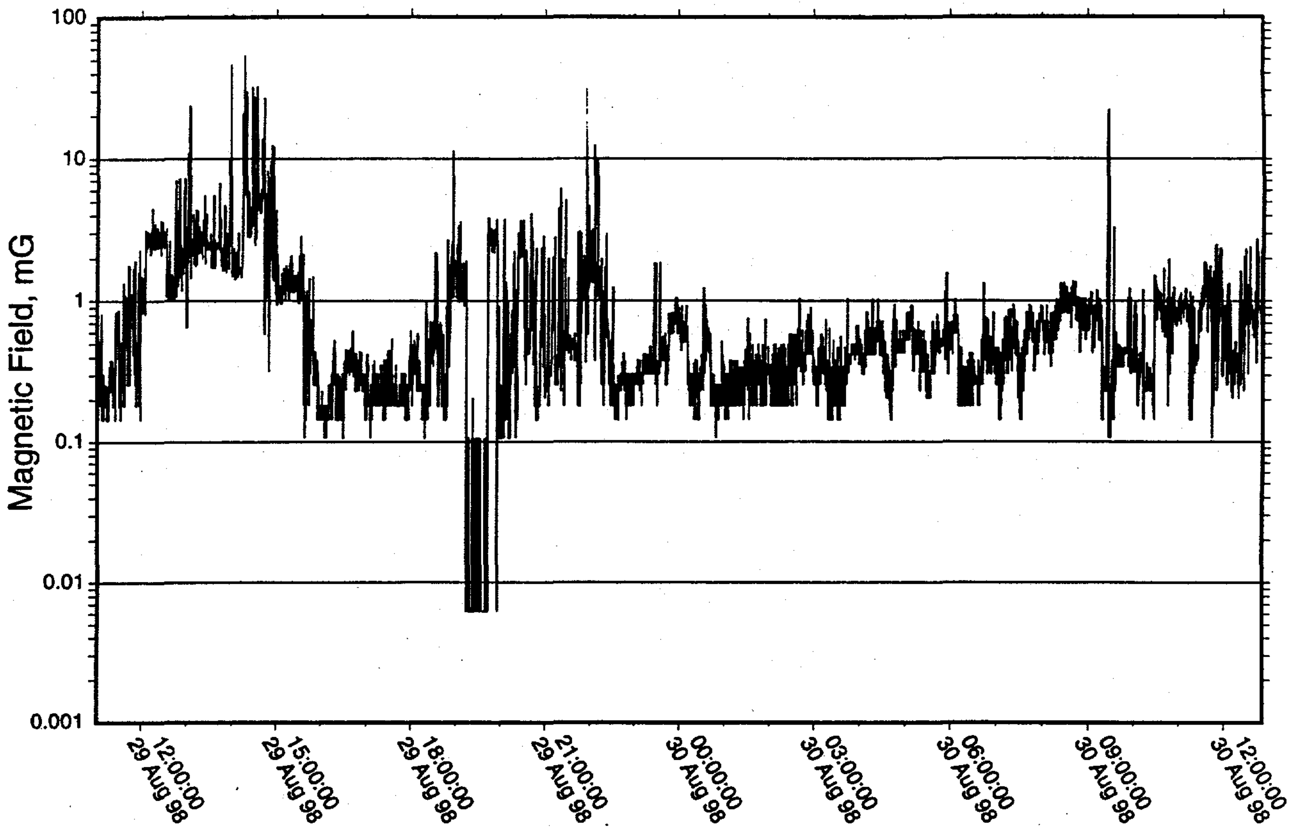


Start date/time	*Location*		*Act*
Wed 08/26 17:28:18	Home	03	175
Wed 08/26 18:00:03	Home	03	219
Wed 08/26 23:10:03	Home	03	174
Thu 08/27 06:30:03	Home	02	136
Thu 08/27 07:45:03	Home	03	226
Thu 08/27 11:10:03	Home	03	173
Thu 08/27 11:45:03	Home	02	69
Thu 08/27 12:30:03	Home	03	220
Thu 08/27 14:30:03	Home	03	128
Thu 08/27 16:30:03	Home	03	108
Thu 08/27 17:47:48	End of data		

Magnetic Field Measurements: Subject No. 7

RAPID7

Unshaded periods include worn measurements

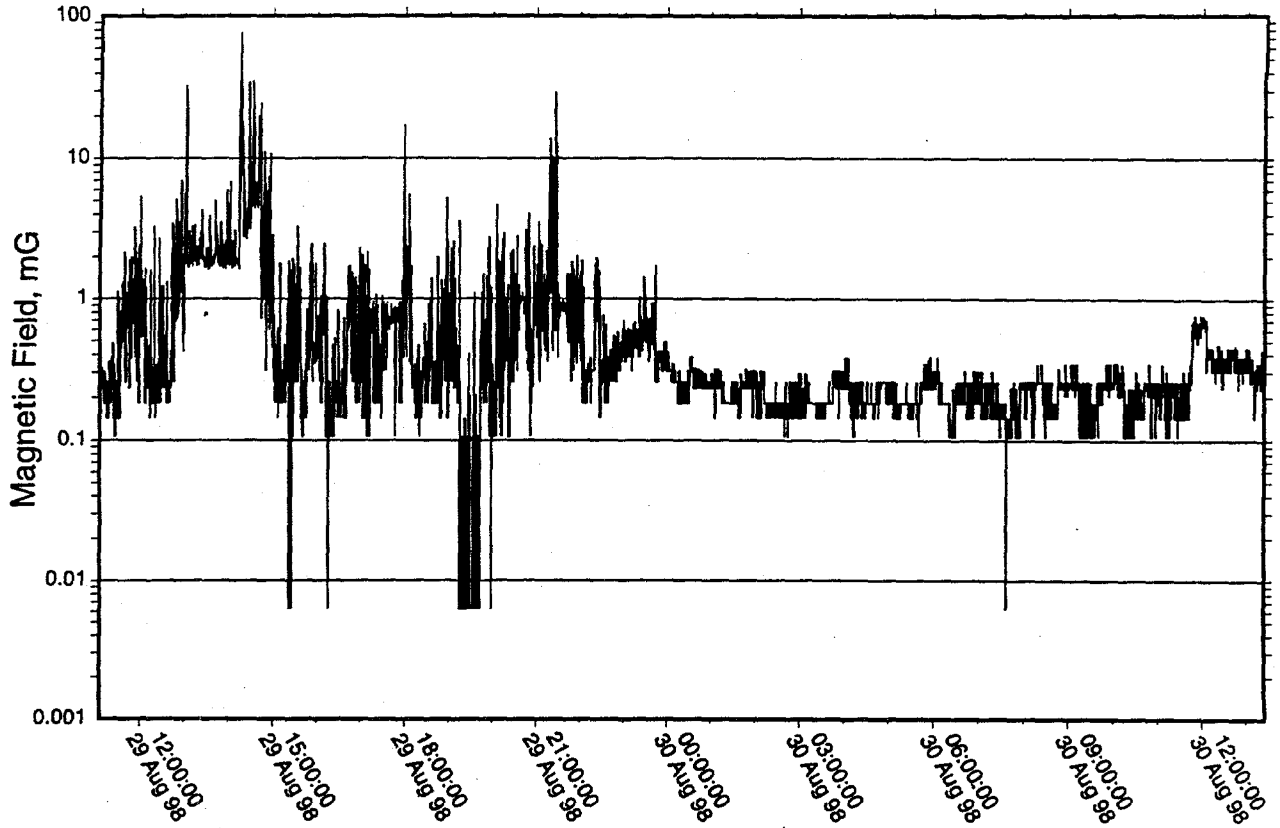


Start date/time	*Location*		*Act*
Sat 08/29 11:01:34	Home	02	114
Sat 08/29 11:45:04	Travel	30	63
Sat 08/29 12:30:04	Other	24	12
Sat 08/29 14:00:04	Travel	30	210
Sat 08/29 14:45:04	Travel	30	39
Sat 08/29 15:15:04	Home	03	188
Sat 08/29 17:00:04	Home	03	24
Sat 08/29 18:00:04	Travel	30	61
Sat 08/29 19:30:04	Other	21	214
Sat 08/29 20:15:04	Travel	30	39
Sat 08/29 21:45:04	Travel	30	66
Sat 08/29 21:55:04	Other	27	10
Sat 08/29 22:15:04	Travel	30	39
Sat 08/29 22:25:04	Home	03	223
Sun 08/30 01:00:04	Home	03	174
Sun 08/30 08:30:04	Home	02	86
Sun 08/30 09:45:04	Home	03	203
Sun 08/30 10:30:04	Home	03	96
Sun 08/30 12:51:54	End of data		

Magnetic Field Measurements: Subject No. 8

RAPID7

Unshaded periods include worn measurements

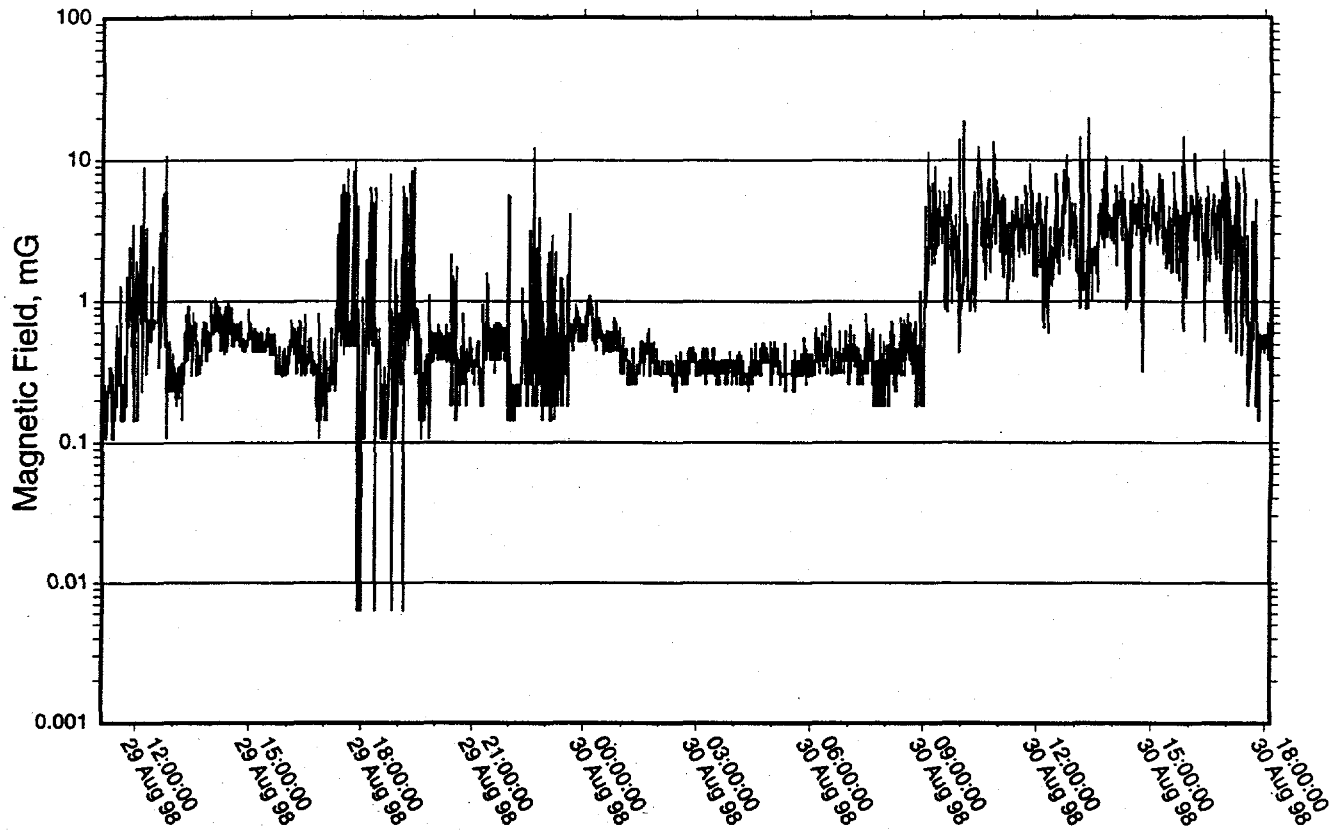


Start date/time	*Location*		*Act*
Sat 08/29 11:04:59	Home	02	114
Sat 08/29 12:30:04	Travel	30	44
Sat 08/29 13:15:04	Other	24	93
Sat 08/29 14:30:04	Other	06	166
Sat 08/29 14:50:04	Travel	30	47
Sat 08/29 15:15:04	Other	27	167
Sat 08/29 15:25:04	Travel	30	39
Sat 08/29 15:40:04	Travel	30	59
Sat 08/29 16:10:04	Other	20	206
Sat 08/29 16:40:04	Travel	30	39
Sat 08/29 16:45:04	Home	03	102
Sat 08/29 18:00:04	Home	03	25
Sat 08/29 18:20:04	Travel	30	60
Sat 08/29 18:45:04	Travel	30	61
Sat 08/29 19:00:04	Other	21	214
Sat 08/29 19:40:04	Travel	30	52
Sat 08/29 19:50:04	Other	27	170
Sat 08/29 20:30:04	Travel	30	39
Sat 08/29 20:40:04	Home	02	28
Sat 08/29 21:20:04	Home	03	15
Sat 08/29 22:10:04	Home	03	217
Sun 08/30 01:00:04	Home	03	174
Sun 08/30 13:24:49	End of data		

Magnetic Field Measurements: Subject No. 9

RAPID7

Unshaded periods include worn measurements

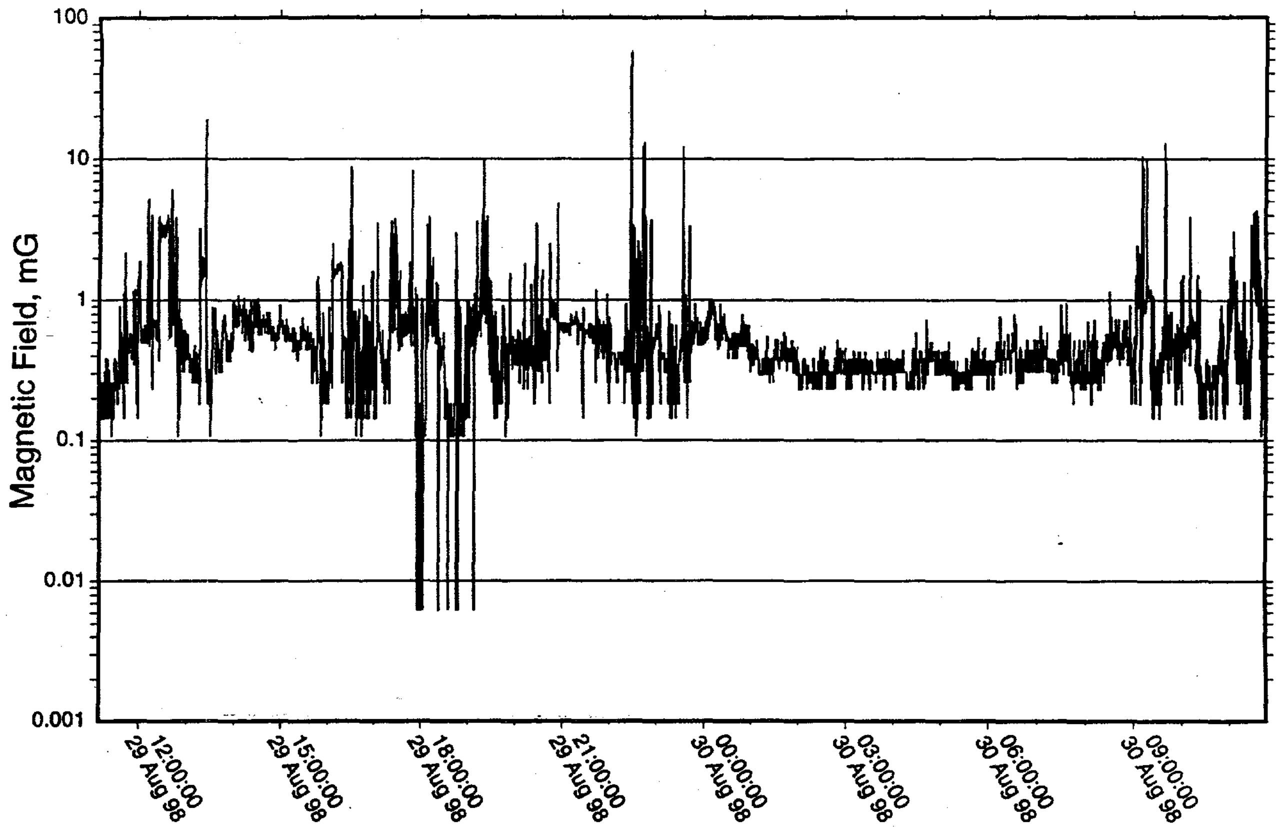


Start date/time	*Location*		*Act*
Sat 08/29 11:08:23	Other	18	114
Sat 08/29 11:30:03	Travel	30	54
Sat 08/29 11:35:03	Other	27	171
Sat 08/29 11:45:03	Travel	30	62
Sat 08/29 12:00:03	Other	24	113
Sat 08/29 12:15:03	Travel	30	39
Sat 08/29 12:30:03	Home	03	70
Sat 08/29 16:30:03	Home	03	78
Sat 08/29 17:30:03	Travel	30	41
Sat 08/29 18:10:03	Other	29	80
Sat 08/29 18:25:03	Travel	30	48
Sat 08/29 18:40:03	Other	27	168
Sat 08/29 19:00:03	Travel	30	39
Sat 08/29 19:15:03	Home	03	150
Sat 08/29 19:35:03	Home	02	103
Sat 08/29 19:55:03	Home	03	221
Sat 08/29 20:10:03	Home	02	36
Sat 08/29 20:45:03	Home	03	222
Sat 08/29 23:35:03	Home	03	174
Sun 08/30 08:30:03	Home	03	77
Sun 08/30 08:55:03	Travel	30	67
Sun 08/30 09:00:03	Work	31	11
Sun 08/30 17:00:03	Other	27	209
Sun 08/30 17:10:03	Travel	30	39
Sun 08/30 17:35:03	Home	03	152
Sun 08/30 18:09:13	End of data		

Magnetic Field Measurements: Subject No. 10

RAPID7

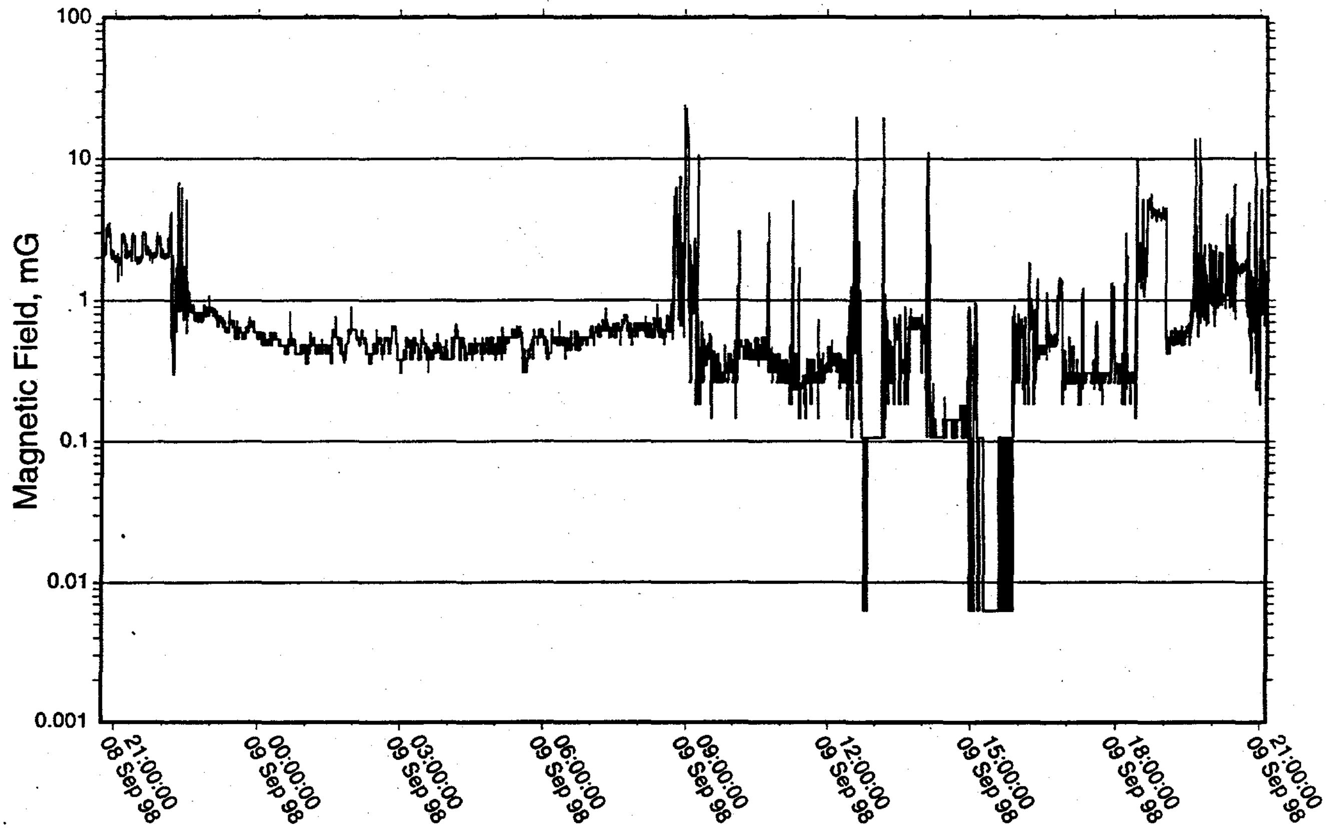
Unshaded periods include worn measurements



Start date/time	*Location*		*Act*
Sat 08/29 11:10:34	Other	12	114
Sat 08/29 11:45:04	Travel	30	235
Sat 08/29 11:55:04	Travel	30	62
Sat 08/29 12:00:04	Other	24	126
Sat 08/29 12:20:04	Travel	30	39
Sat 08/29 12:30:04	Home	03	164
Sat 08/29 14:30:04	Home	03	147
Sat 08/29 16:00:04	Home	03	240
Sat 08/29 16:30:04	Travel	30	41
Sat 08/29 17:00:04	Other	29	230
Sat 08/29 17:20:04	Travel	30	48
Sat 08/29 17:40:04	Other	27	168
Sat 08/29 19:00:04	Travel	30	39
Sat 08/29 19:30:04	Home	02	6
Sat 08/29 19:40:04	Home	03	228
Sat 08/29 20:10:04	Home	03	239
Sat 08/29 21:10:04	Home	03	101
Sat 08/29 22:10:04	Home	02	229
Sat 08/29 23:30:04	Home	03	221
Sat 08/29 23:50:04	Home	03	174
Sun 08/30 08:50:04	Home	02	73
Sun 08/30 09:20:04	Home	03	105
Sun 08/30 10:20:04	Home	03	190
Sun 08/30 11:00:04	Other	19	211
Sun 08/30 11:20:04	Travel	30	51
Sun 08/30 11:46:04	End of data		

Magnetic Field Measurements: Subject No. 11 RAPID7

Unshaded periods include worn measurements

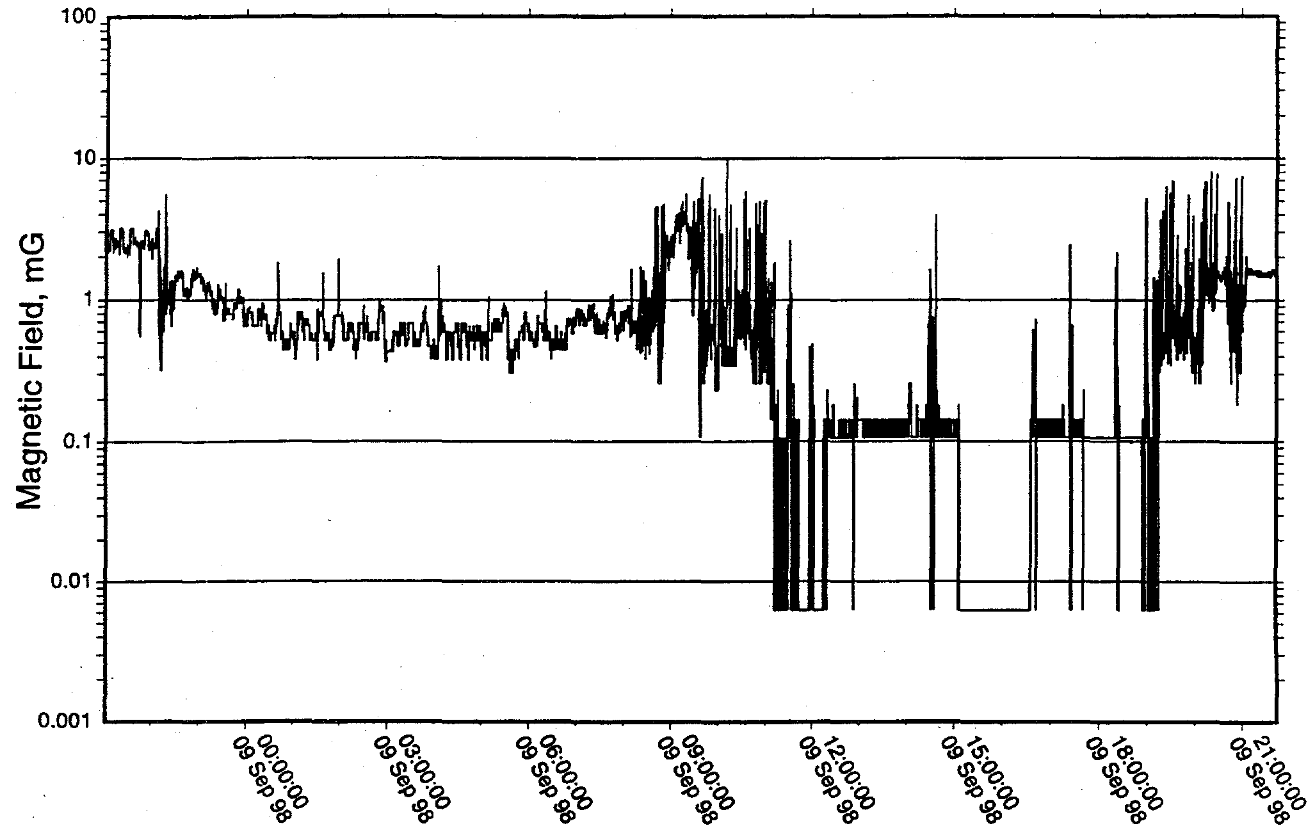


Start date/time	*Location*		*Act*
Tue 09/08 20:44:50	Other	24	94
Tue 09/08 22:15:00	Travel	30	213
Tue 09/08 22:30:00	Home	03	174
Wed 09/09 07:15:00	Home	03	85
Wed 09/09 08:41:00	Travel	30	67
Wed 09/09 08:57:00	Other	23	179
Wed 09/09 09:13:00	Travel	30	67
Wed 09/09 09:23:00	Work	31	11
Wed 09/09 18:27:00	Travel	30	39
Wed 09/09 18:40:00	Home	03	147
Wed 09/09 19:30:00	Home	02	123
Wed 09/09 20:35:00	Travel	30	225
Wed 09/09 21:08:35	End of data		

Magnetic Field Measurements: Subject No. 12

Unshaded periods include worn measurements

RAPID7

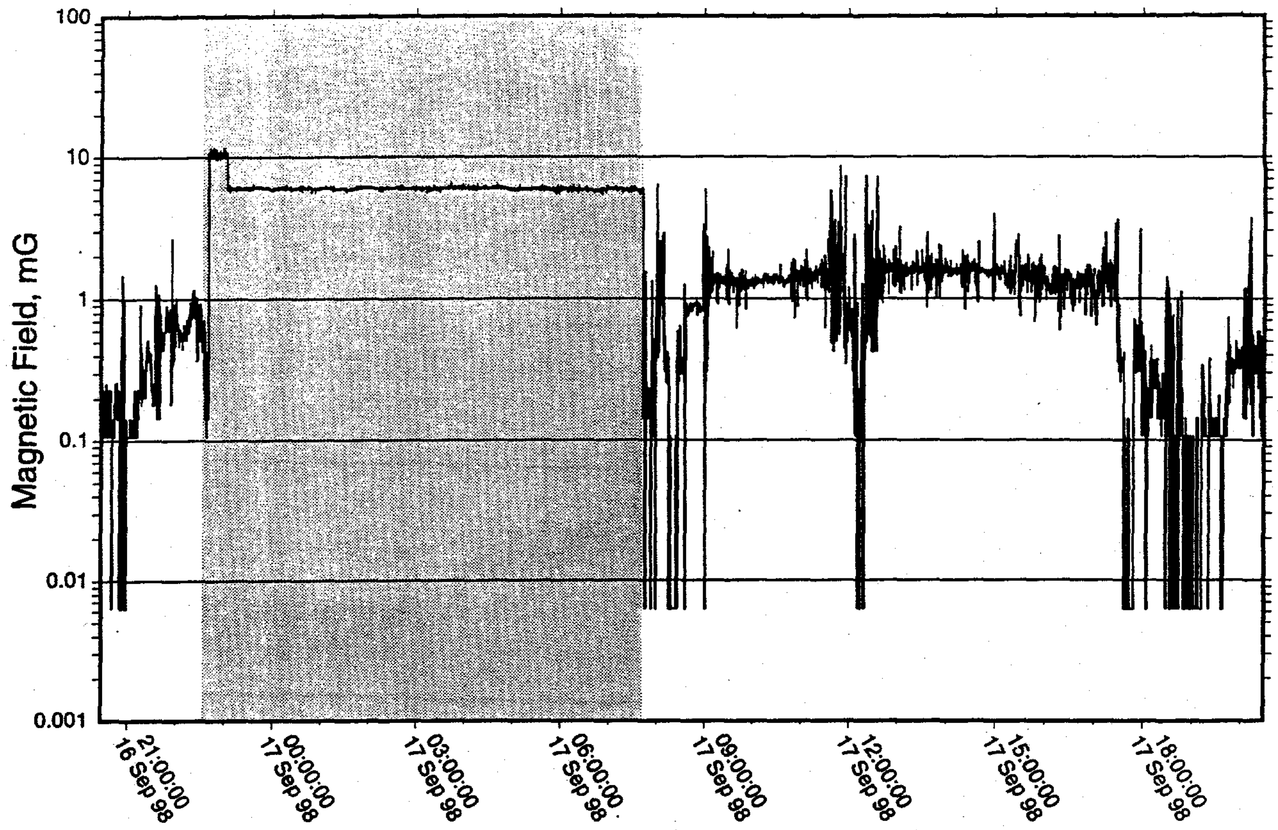


Start date/time	Location		Act
Tue 09/08 21:03:39	Other	24	31
Tue 09/08 22:00:04	Travel	30	213
Tue 09/08 22:30:04	Home	03	174
Wed 09/09 07:00:04	Home	03	85
Wed 09/09 08:30:04	Travel	30	216
Wed 09/09 08:40:04	Other	24	14
Wed 09/09 09:30:04	Travel	30	213
Wed 09/09 09:40:04	Travel	30	67
Wed 09/09 11:00:04	Work	31	238
Wed 09/09 19:15:04	Travel	30	39
Wed 09/09 20:10:04	Home	02	15
Wed 09/09 20:30:04	Travel	30	225
Wed 09/09 21:44:39	End of data		

Magnetic Field Measurements: Subject No. 13

RAPID7

Unshaded periods include worn measurements

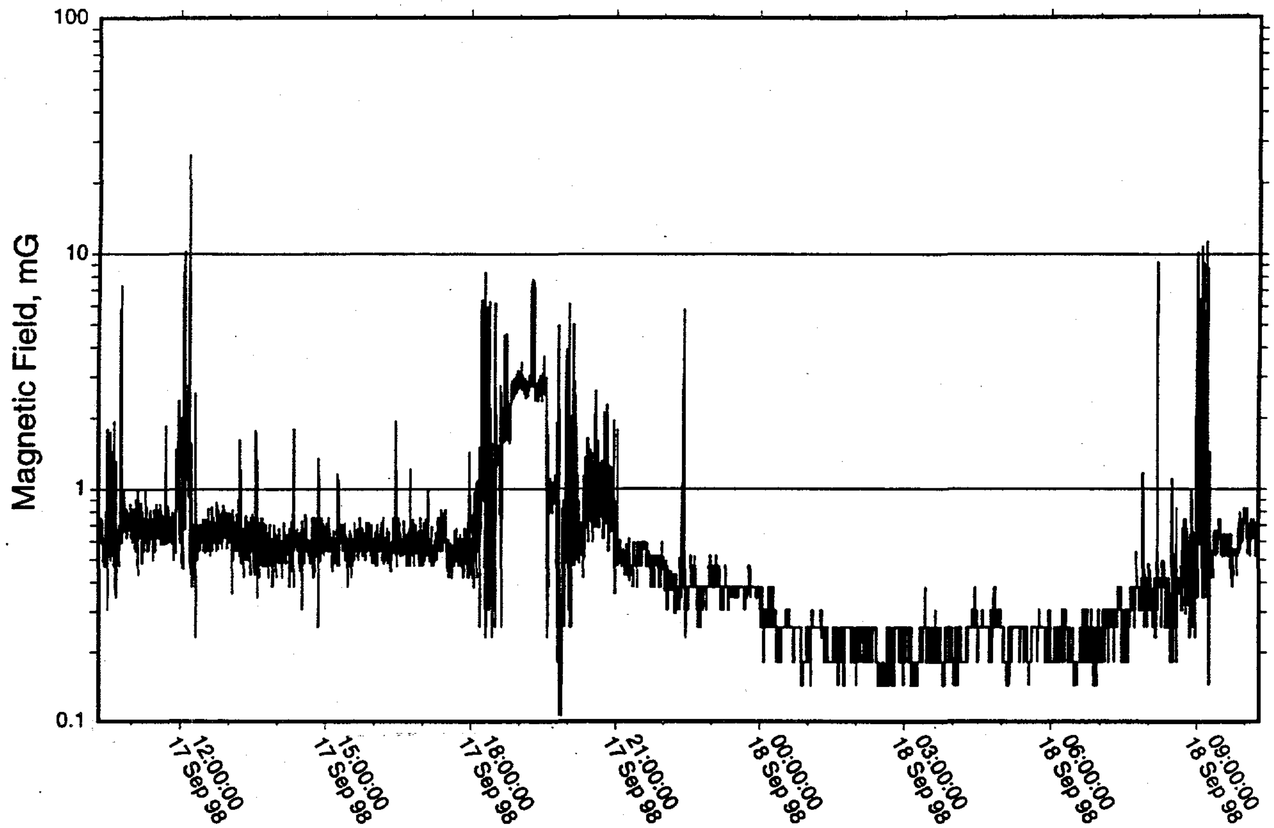


Start date/time	*Location*		*Act*
Wed 09/16 20:27:46	**Home**	**03**	**178**
Wed 09/16 21:34:01	**Home**	**03**	**218**
Wed 09/16 22:33:01	Excluded		174
Thu 09/17 07:42:01	**Home**	**02**	**85**
Thu 09/17 07:55:01	**Travel**	**30**	**56**
Thu 09/17 08:10:01	**Other**	**21**	**212**
Thu 09/17 08:30:01	**Travel**	**30**	**67**
Thu 09/17 09:04:01	**Work**	**31**	**241**
Thu 09/17 11:27:01	**Travel**	**30**	**107**
Thu 09/17 12:08:01	**Home**	**02**	**5**
Thu 09/17 12:17:01	**Travel**	**30**	**67**
Thu 09/17 12:36:01	**Work**	**31**	**241**
Thu 09/17 17:23:01	**Travel**	**30**	**56**
Thu 09/17 17:30:01	**Other**	**21**	**212**
Thu 09/17 17:50:01	**Travel**	**30**	**39**
Thu 09/17 17:58:01	**Home**	**02**	**5**
Thu 09/17 20:28:36	**End of data**		

RAPID7

Magnetic Field Measurements: Subject No. 14

Unshaded periods include worn measurements

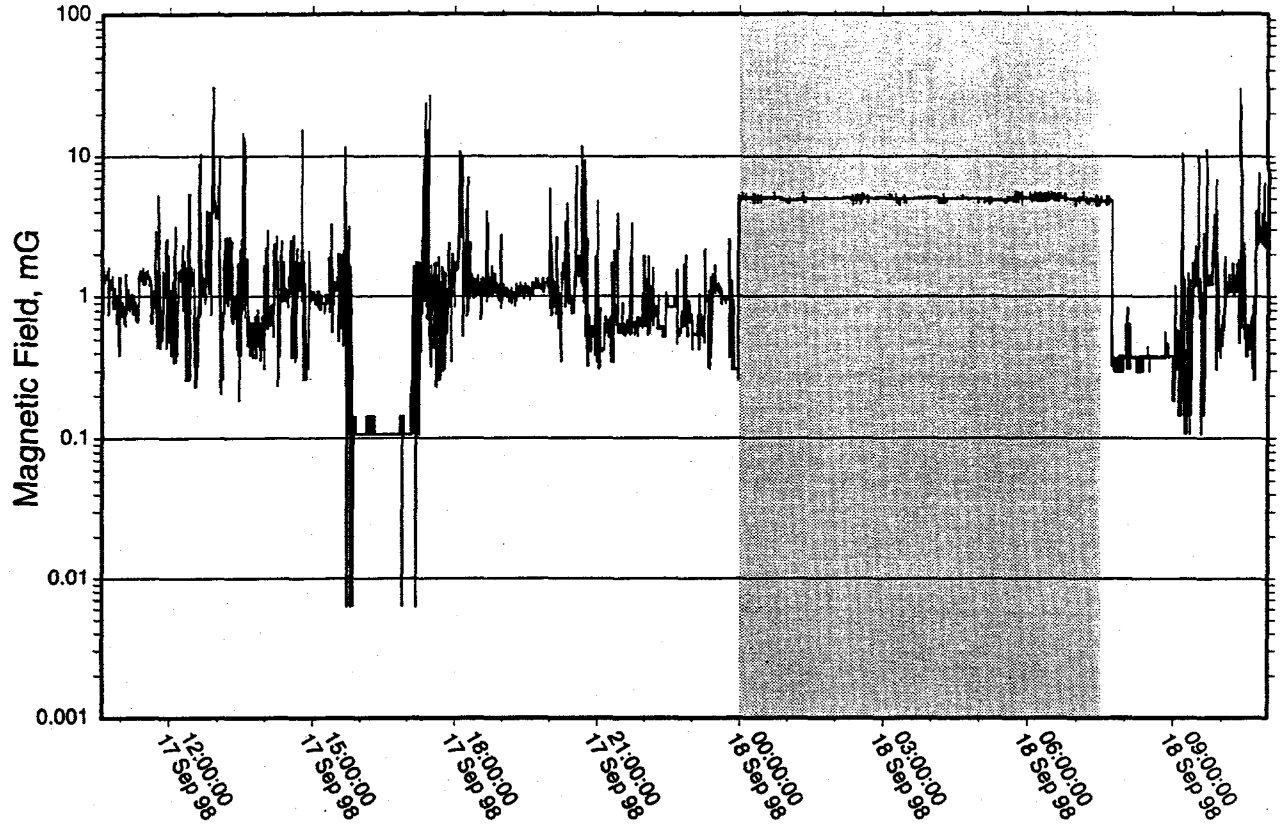


Start date/time	*Location*	*Act*
Thu 09/17 10:19:36	Work 31	178
Thu 09/17 10:29:01	Work 31	241
Thu 09/17 11:58:01	Travel 30	215
Thu 09/17 12:15:01	Work 31	241
Thu 09/17 18:05:01	Travel 30	49
Thu 09/17 18:35:01	Other 14	72
Thu 09/17 19:51:01	Travel 30	39
Thu 09/17 20:01:01	Home 03	149
Thu 09/17 20:18:01	Home 02	27
Thu 09/17 20:58:01	Home 03	91
Thu 09/17 21:15:01	Home 03	23
Thu 09/17 21:18:01	Home 03	219
Thu 09/17 22:19:01	Home 03	135
Thu 09/17 22:30:01	Home 03	174
Fri 09/18 07:45:01	Home 03	90
Fri 09/18 08:11:01	Home 03	85
Fri 09/18 08:40:01	Home 02	89
Fri 09/18 08:58:01	Travel 30	67
Fri 09/18 09:08:01	Work 31	241
Fri 09/18 10:17:31	End of data	

Magnetic Field Measurements: Subject No. 15

RAPID7

Unshaded periods include worn measurements

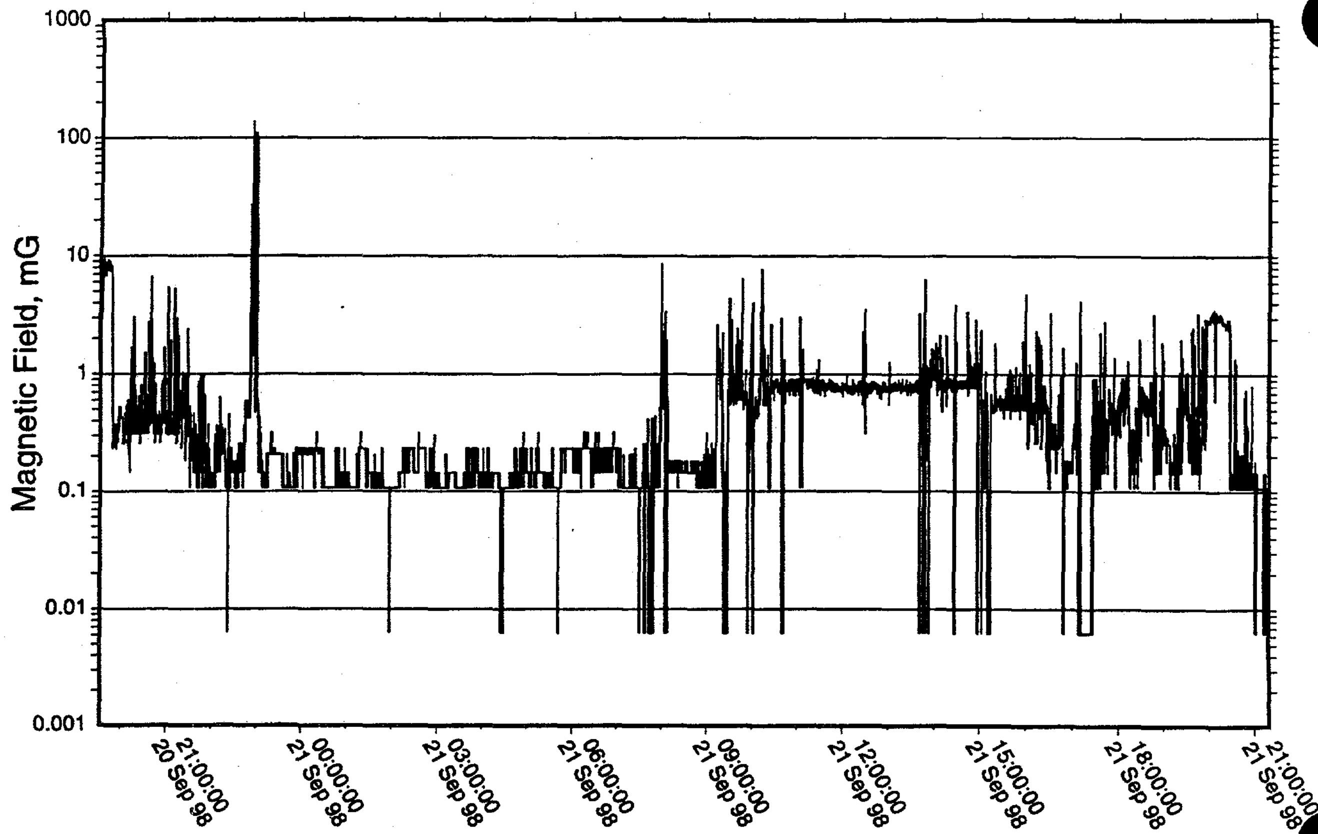


Start date/time	Location	Act
Thu 09/17 10:36:28	**Work 31**	**178**
Thu 09/17 20:30:03	**Travel 30**	**162**
Thu 09/17 21:00:03	**Home 03**	**92**
Fri 09/18 00:00:03	Excluded	174
Fri 09/18 05:50:03	Excluded	163
Fri 09/18 07:30:03	**Work 31**	**242**
Fri 09/18 09:30:03	**Work 31**	**140**
Fri 09/18 10:57:23	**End of data**	

Magnetic Field Measurements: Subject No. 16

RAPID7

Unshaded periods include worn measurements

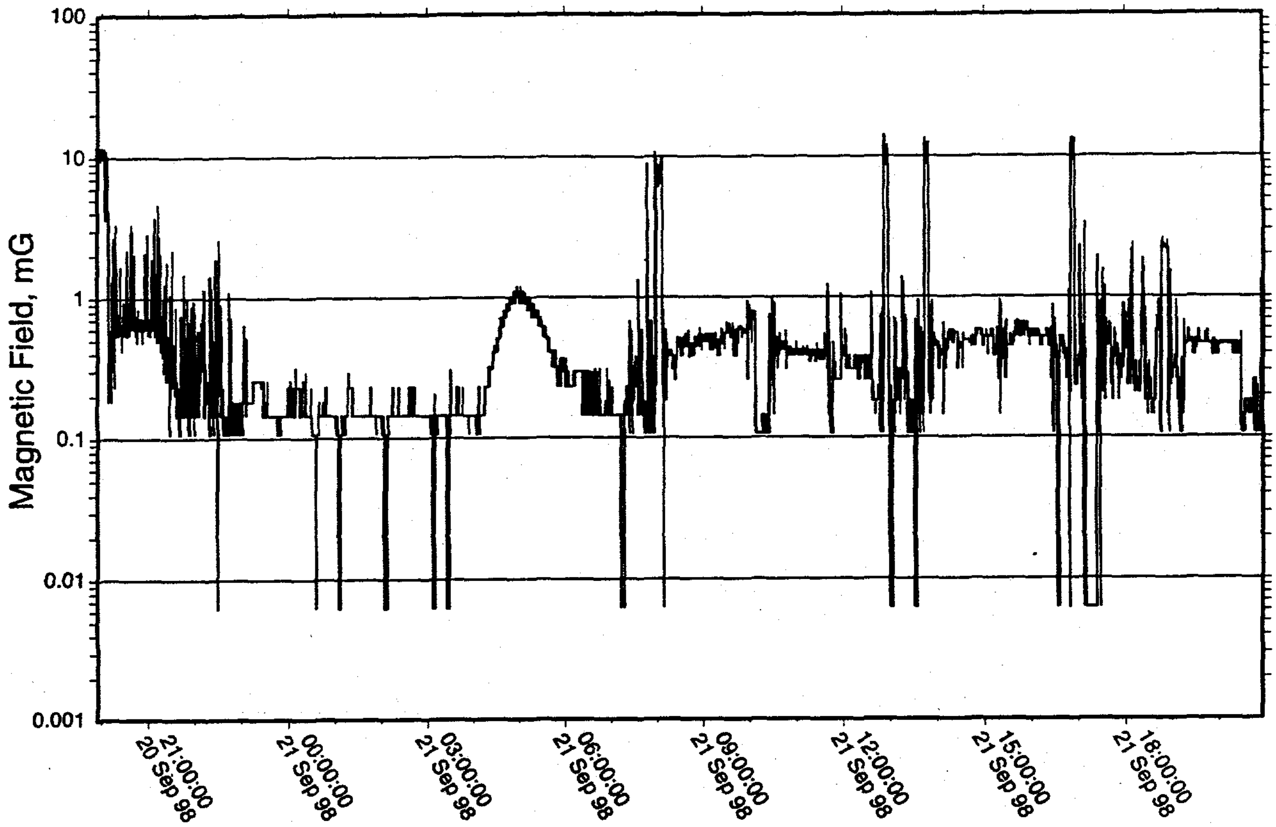


Start date/time	*Location*		*Act*
Sun 09/20 19:33:27	Other	15	18
Sun 09/20 20:07:02	Travel	30	39
Sun 09/20 21:15:02	Home	02	3
Sun 09/20 22:20:02	Home	03	141
Sun 09/20 23:06:02	Home	03	174
Mon 09/21 07:33:02	Home	03	87
Mon 09/21 07:57:02	Travel	30	53
Mon 09/21 08:04:02	Other	14	246
Mon 09/21 09:12:02	Travel	30	45
Mon 09/21 10:05:02	Other	08	181
Mon 09/21 10:10:02	Travel	30	52
Mon 09/21 10:15:02	Other	13	180
Mon 09/21 10:18:02	Travel	30	67
Mon 09/21 10:25:02	Work	31	241
Mon 09/21 15:03:02	Travel	30	64
Mon 09/21 16:01:02	Travel	30	42
Mon 09/21 16:10:02	Other	04	106
Mon 09/21 16:15:02	Travel	30	39
Mon 09/21 16:20:02	Home	03	149
Mon 09/21 17:01:02	Travel	30	211
Mon 09/21 17:32:02	Home	03	224
Mon 09/21 21:00:02	Home	03	26
Mon 09/21 21:19:07	End of data		

Magnetic Field Measurements: Subject No. 17

RAPID7

Unshaded periods include worn measurements

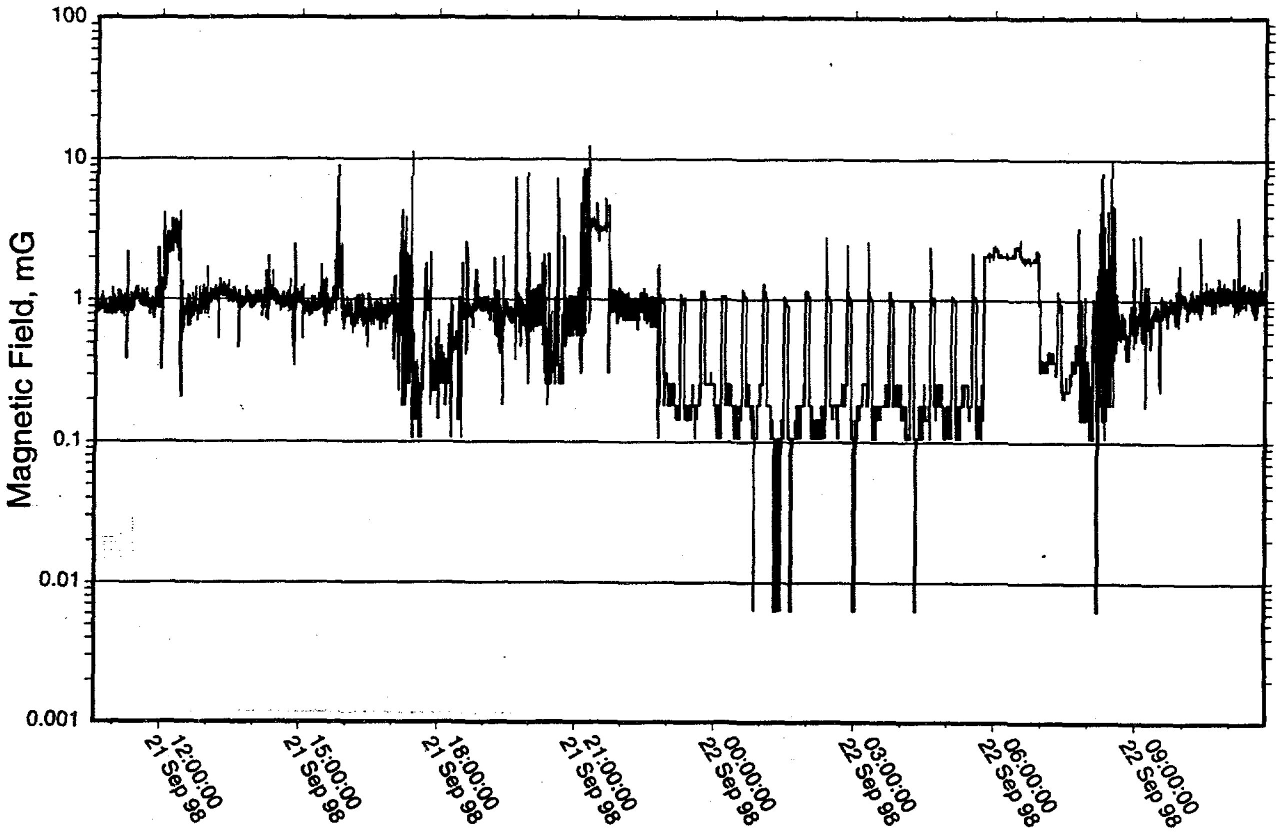


Start date/time	Location		Act
Sun 09/20 19:54:30	Other	15	18
Sun 09/20 20:15:00	Travel	30	39
Sun 09/20 21:20:00	Home	03	182
Sun 09/20 22:30:00	Home	03	20
Sun 09/20 23:00:00	Home	03	174
Mon 09/21 07:10:00	Travel	30	208
Mon 09/21 07:30:00	Home	02	35
Mon 09/21 07:45:00	Travel	30	159
Mon 09/21 08:00:00	Work	31	236
Mon 09/21 12:44:00	Travel	30	157
Mon 09/21 12:55:00	Home	02	16
Mon 09/21 13:45:00	Travel	30	159
Mon 09/21 13:55:00	Work	31	236
Mon 09/21 15:15:00	Work	31	119
Mon 09/21 15:17:00	Work	31	124
Mon 09/21 16:39:00	Travel	30	156
Mon 09/21 16:50:00	Travel	30	211
Mon 09/21 17:30:00	Home	03	5
Mon 09/21 18:15:00	Travel	30	57
Mon 09/21 18:20:00	Other	13	111
Mon 09/21 18:22:00	Travel	30	39
Mon 09/21 18:23:00	Home	03	183
Mon 09/21 20:56:00	End of data		

Magnetic Field Measurements: Subject No. 18

Unshaded periods include worn measurements

RAPID7

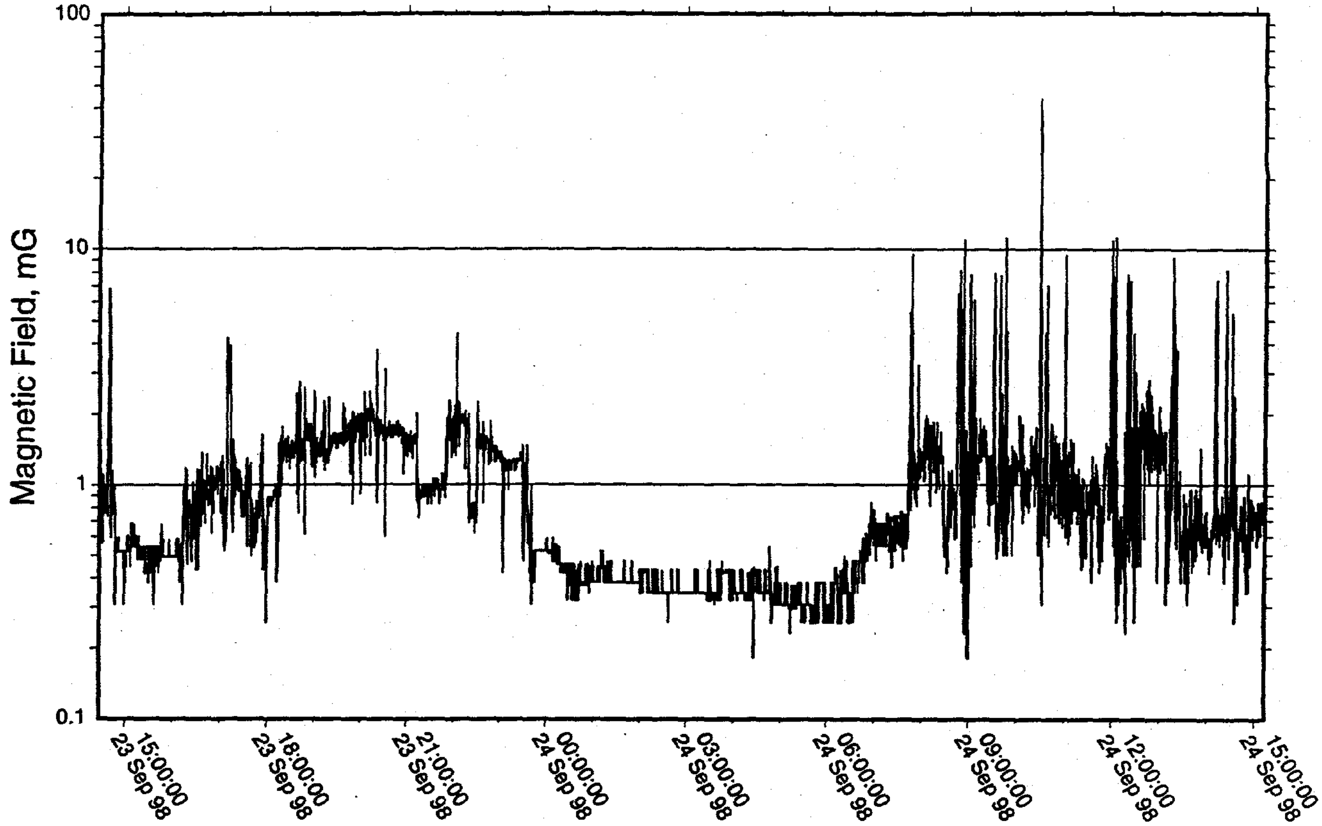


Start date/time	Location		Act
Mon 09/21 10:36:10	Work	31	18
Mon 09/21 10:45:00	Work	31	176
Mon 09/21 12:00:00	Travel	30	231
Mon 09/21 12:05:00	Other	24	13
Mon 09/21 12:30:00	Travel	30	154
Mon 09/21 12:35:00	Work	31	238
Mon 09/21 17:04:00	Travel	30	39
Mon 09/21 17:29:00	Home	02	28
Mon 09/21 18:00:00	Home	03	239
Mon 09/21 19:39:00	Home	03	146
Mon 09/21 20:19:00	Home	02	122
Mon 09/21 20:43:00	Home	03	143
Mon 09/21 21:07:00	Home	03	84
Mon 09/21 21:17:00	Home	03	144
Mon 09/21 21:43:00	Home	03	219
Mon 09/21 22:47:00	Home	03	227
Tue 09/22 07:46:00	Home	03	83
Tue 09/22 08:05:00	Travel	30	67
Tue 09/22 08:37:00	Work	31	2
Tue 09/22 11:47:20	End of data		

Magnetic Field Measurements: Subject No. 19

Unshaded periods include worn measurements

RAPID7

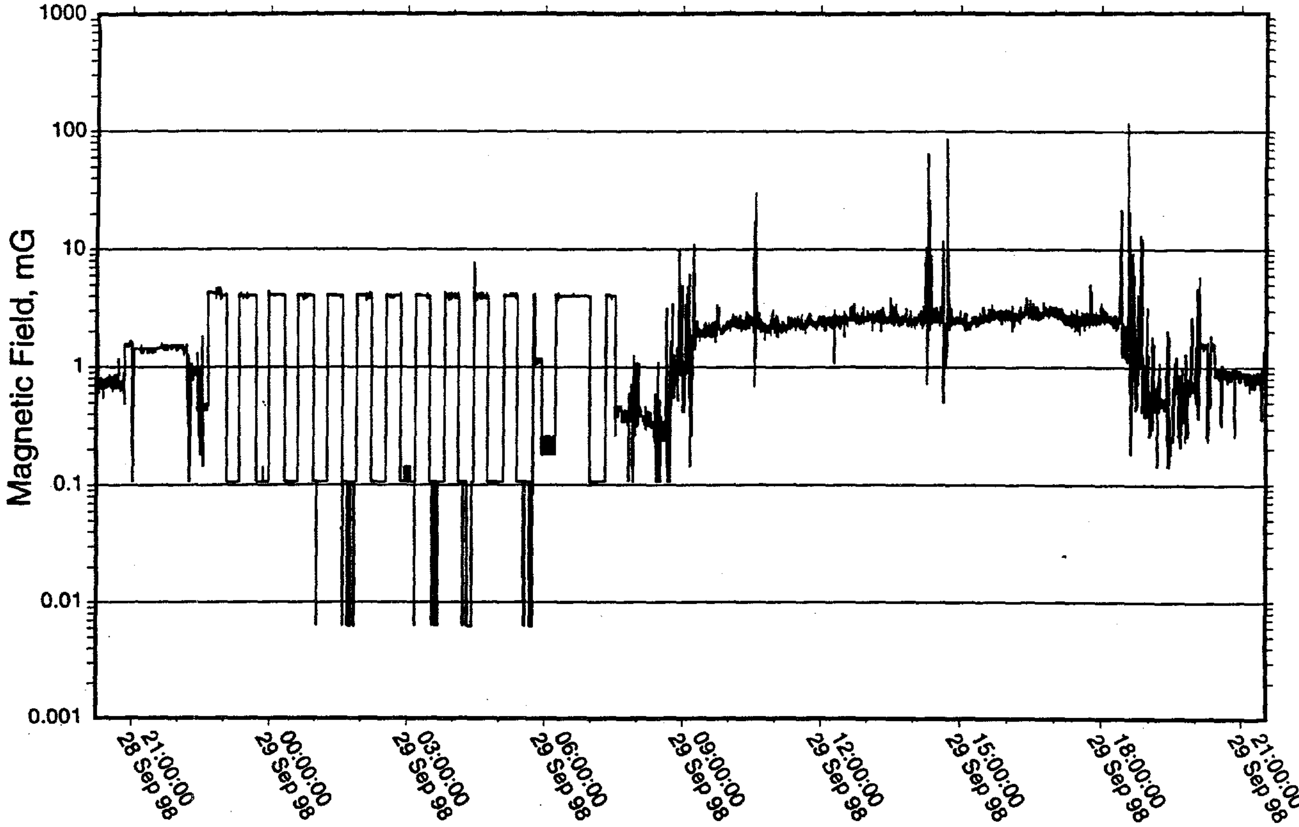


Start date/time			*Location*		*Act*
Wed	09/23	14:26:49	Home	03	18
Wed	09/23	14:45:04	Home	03	186
Wed	09/23	16:07:04	Home	02	148
Wed	09/23	23:30:04	Home	03	174
Thu	09/24	07:30:04	Home	02	118
Thu	09/24	08:45:04	Travel	30	65
Thu	09/24	09:00:04	School	25	9
Thu	09/24	09:05:04	Travel	30	39
Thu	09/24	09:15:04	Home	03	98
Thu	09/24	11:45:04	Travel	30	65
Thu	09/24	12:00:04	School	25	9
Thu	09/24	12:15:04	Travel	30	55
Thu	09/24	12:30:04	Other	24	116
Thu	09/24	13:15:04	Travel	30	39
Thu	09/24	13:30:04	Home	03	98
Thu	09/24	15:12:34	End of data		

Magnetic Field Measurements: Subject No. 20

RAPID7

Unshaded periods include worn measurements

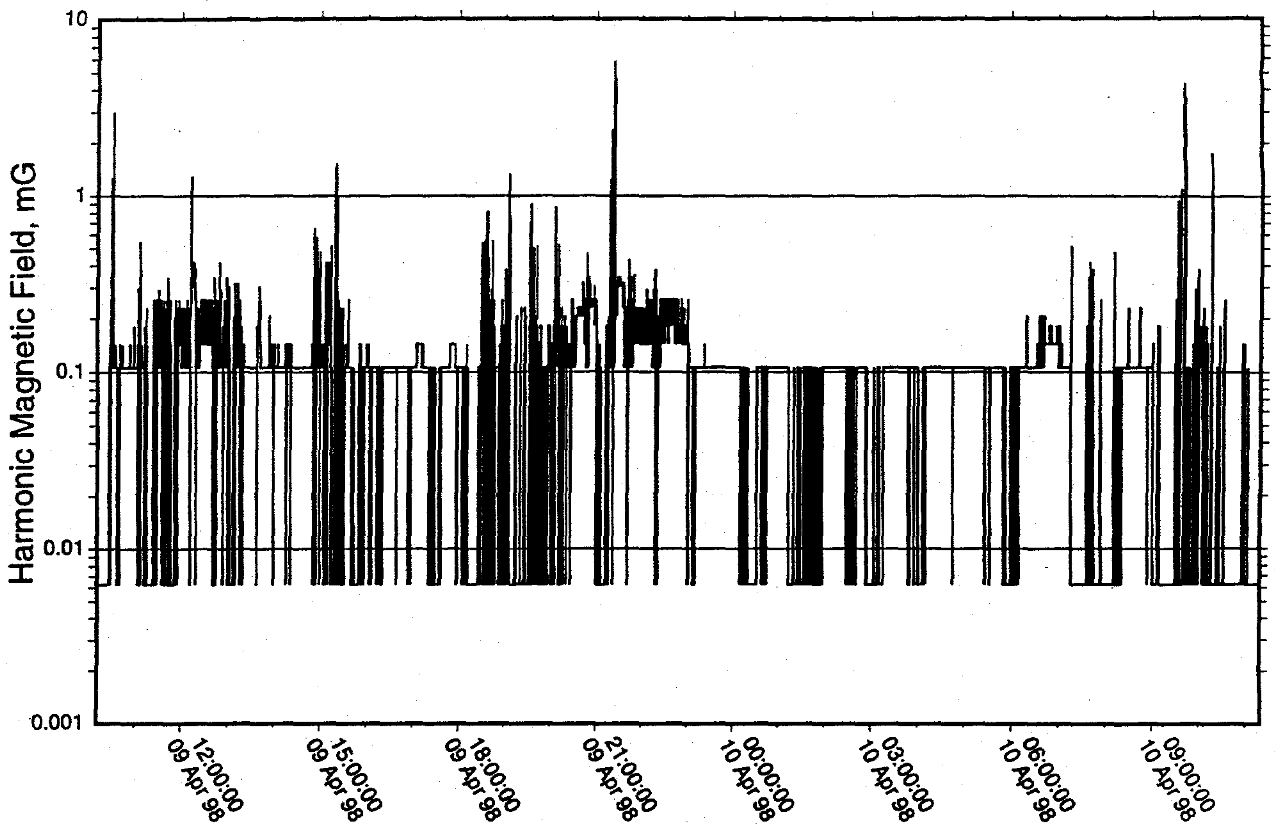


Start date/time			*Location*		*Act*
Mon	09/28	20:15:18	Home	03	18
Mon	09/28	22:15:03	Home	03	84
Mon	09/28	22:30:03	Home	03	174
Tue	09/29	07:31:03	Home	03	202
Tue	09/29	07:32:03	Home	03	82
Tue	09/29	08:30:03	Travel	30	43
Tue	09/29	09:05:03	Travel	30	155
Tue	09/29	09:15:03	Work	31	161
Tue	09/29	09:16:03	Work	31	177
Tue	09/29	09:27:03	Work	31	201
Tue	09/29	10:09:03	Work	31	199
Tue	09/29	10:16:03	Work	31	138
Tue	09/29	10:33:03	Work	31	161
Tue	09/29	10:36:03	Work	31	30
Tue	09/29	14:11:03	Work	31	200
Tue	09/29	14:17:03	Work	31	139
Tue	09/29	14:20:03	Work	31	95
Tue	09/29	14:40:03	Work	31	138
Tue	09/29	14:42:03	Work	31	161
Tue	09/29	18:21:03	Work	31	160
Tue	09/29	18:22:03	Work	31	139
Tue	09/29	18:31:03	Travel	30	158
Tue	09/29	18:40:03	Travel	30	39
Tue	09/29	18:59:03	Home	02	74
Tue	09/29	21:33:03	End of data		

Harmonic Magnetic Field Measurements: Subject No. 1

RAPID7

Unshaded periods include worn measurements

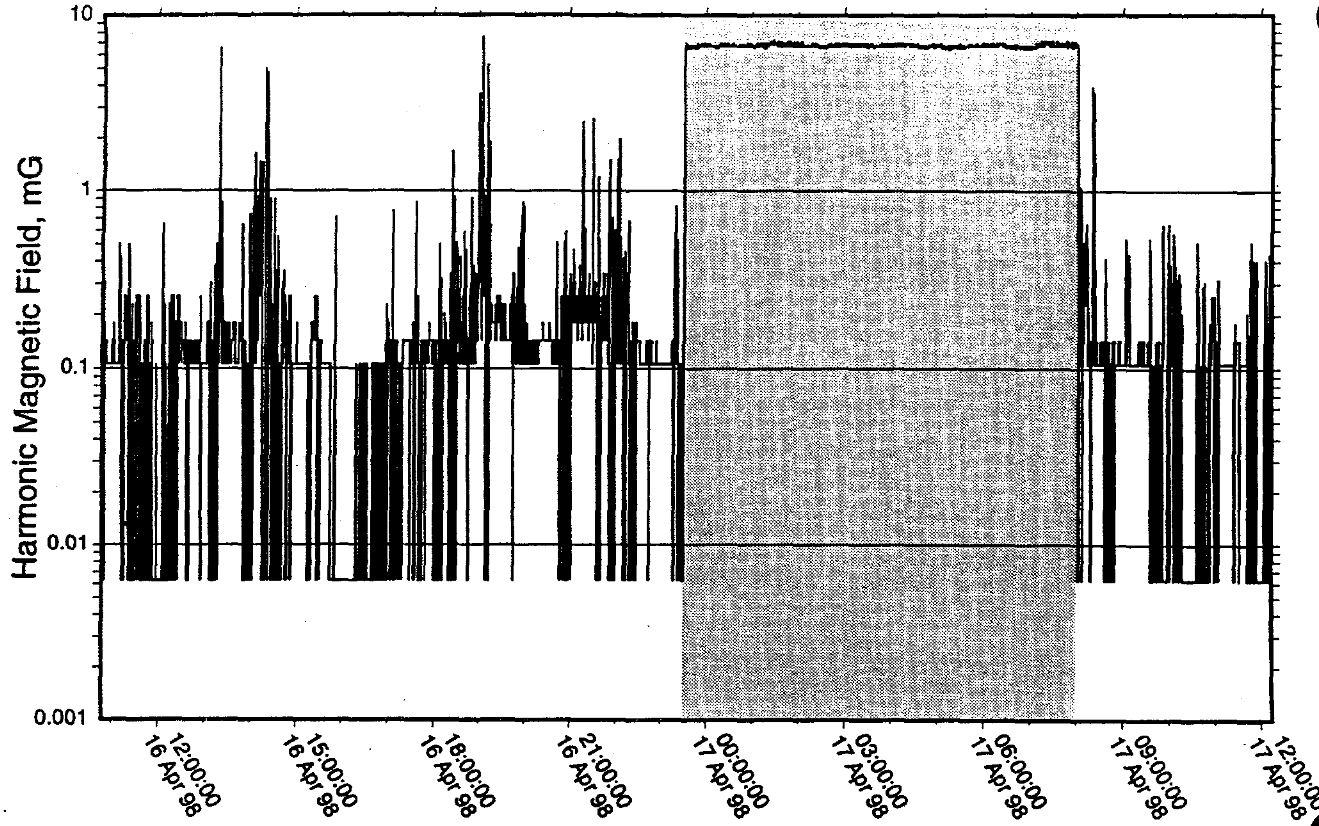


Start date/time			Location		Act
Thu	04/09	10:11:14	Home	01	21
Thu	04/09	10:35:04	Home	01	244
Thu	04/09	12:35:04	Travel	30	46
Thu	04/09	13:10:04	Other	26	192
Thu	04/09	15:00:04	Travel	30	197
Thu	04/09	15:10:04	Other	05	4
Thu	04/09	15:20:04	Travel	30	196
Thu	04/09	15:30:04	Home	01	125
Thu	04/09	18:10:04	Home	01	79
Thu	04/09	18:30:04	Travel	30	193
Thu	04/09	18:45:04	Other	22	8
Thu	04/09	18:55:04	Other	16	7
Thu	04/09	19:30:04	Travel	30	198
Thu	04/09	19:45:04	Other	27	169
Thu	04/09	20:00:04	Travel	30	196
Thu	04/09	20:10:04	Home	01	219
Thu	04/09	20:30:04	Home	01	134
Thu	04/09	21:15:04	Home	01	120
Thu	04/09	21:30:04	Home	01	109
Thu	04/09	23:00:04	Home	01	233
Fri	04/10	06:15:04	Home	01	104
Fri	04/10	07:17:04	Home	01	191
Fri	04/10	07:36:04	Home	01	130
Fri	04/10	08:00:04	Home	01	189
Fri	04/10	09:00:04	Home	01	99
Fri	04/10	11:19:59	End of data		

Harmonic Magnetic Field Measurements: Subject No. 2

Unshaded periods include worn measurements

RAPID7

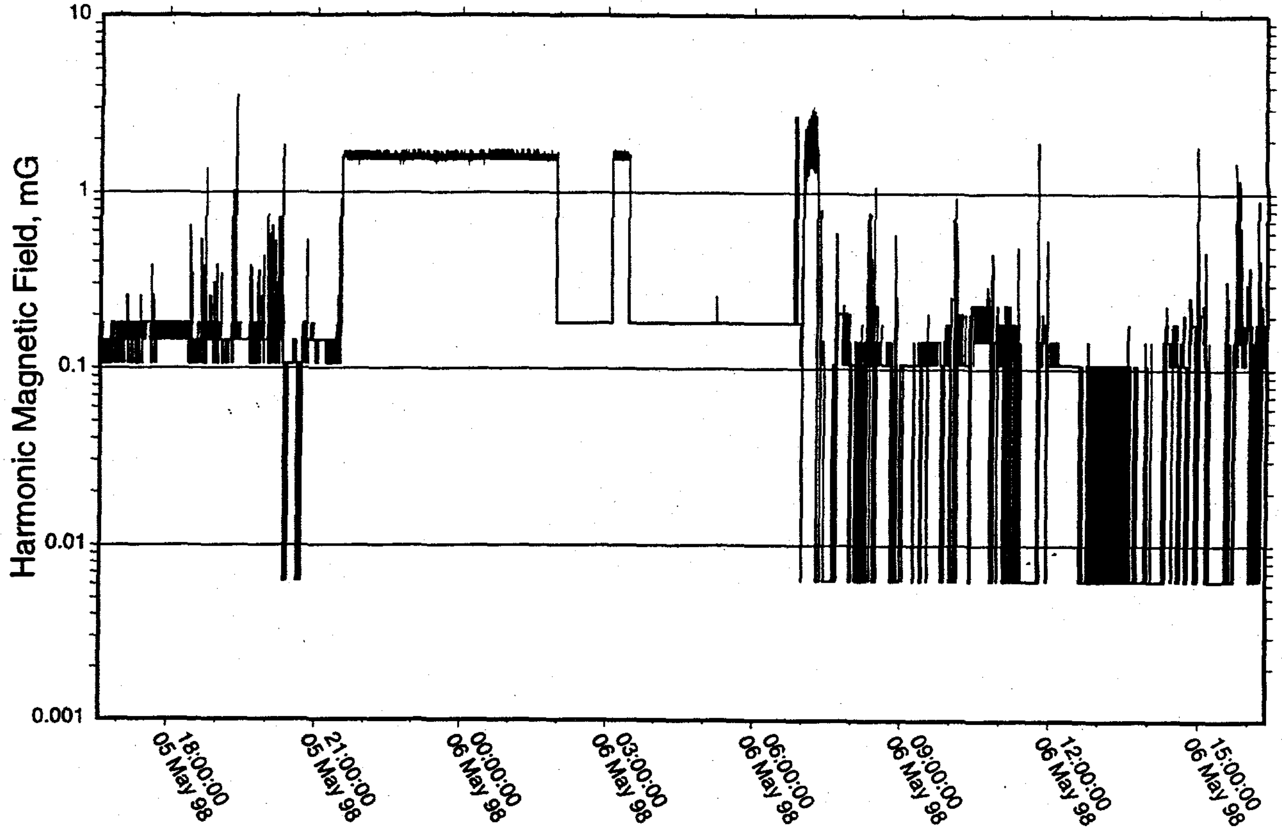


Start date/time	*Location*		*Act*
Thu 04/16 10:47:14	**Home**	**02**	**33**
Thu 04/16 11:09:04	**Home**	**03**	**127**
Thu 04/16 11:15:04	**Home**	**03**	**243**
Thu 04/16 13:20:04	**Home**	**02**	**121**
Thu 04/16 13:50:04	**Travel**	**30**	**58**
Thu 04/16 13:55:04	**Other**	**28**	**172**
Thu 04/16 14:25:04	**Travel**	**30**	**193**
Thu 04/16 14:30:04	**Home**	**03**	**109**
Thu 04/16 18:00:04	**Travel**	**30**	**195**
Thu 04/16 18:25:04	**Home**	**02**	**137**
Thu 04/16 19:15:04	**Home**	**02**	**32**
Thu 04/16 20:00:04	**Home**	**03**	**243**
Thu 04/16 20:45:04	**Travel**	**30**	**194**
Thu 04/16 22:10:04	**Home**	**03**	**243**
Thu 04/16 22:30:04	**Home**	**03**	**97**
Thu 04/16 23:10:04	**Home**	**03**	**76**
Thu 04/16 23:30:04	Excluded		232
Fri 04/17 08:00:04	**Home**	**02**	**88**
Fri 04/17 09:35:04	**Home**	**02**	**245**
Fri 04/17 09:50:04	**Home**	**03**	**234**
Fri 04/17 09:55:04	**Home**	**02**	**110**
Fri 04/17 10:05:04	**Travel**	**30**	**187**
Fri 04/17 10:12:04	**Other**	**17**	**205**
Fri 04/17 10:40:04	**Home**	**03**	**109**
Fri 04/17 11:45:04	**Travel**	**30**	**132**
Fri 04/17 11:50:04	**Other**	**21**	**112**
Fri 04/17 12:00:04	**Travel**	**30**	**153**
Fri 04/17 12:14:09	**End of data**		

Harmonic Magnetic Field Measurements: Subject No. 3

RAPID7

Unshaded periods include worn measurements

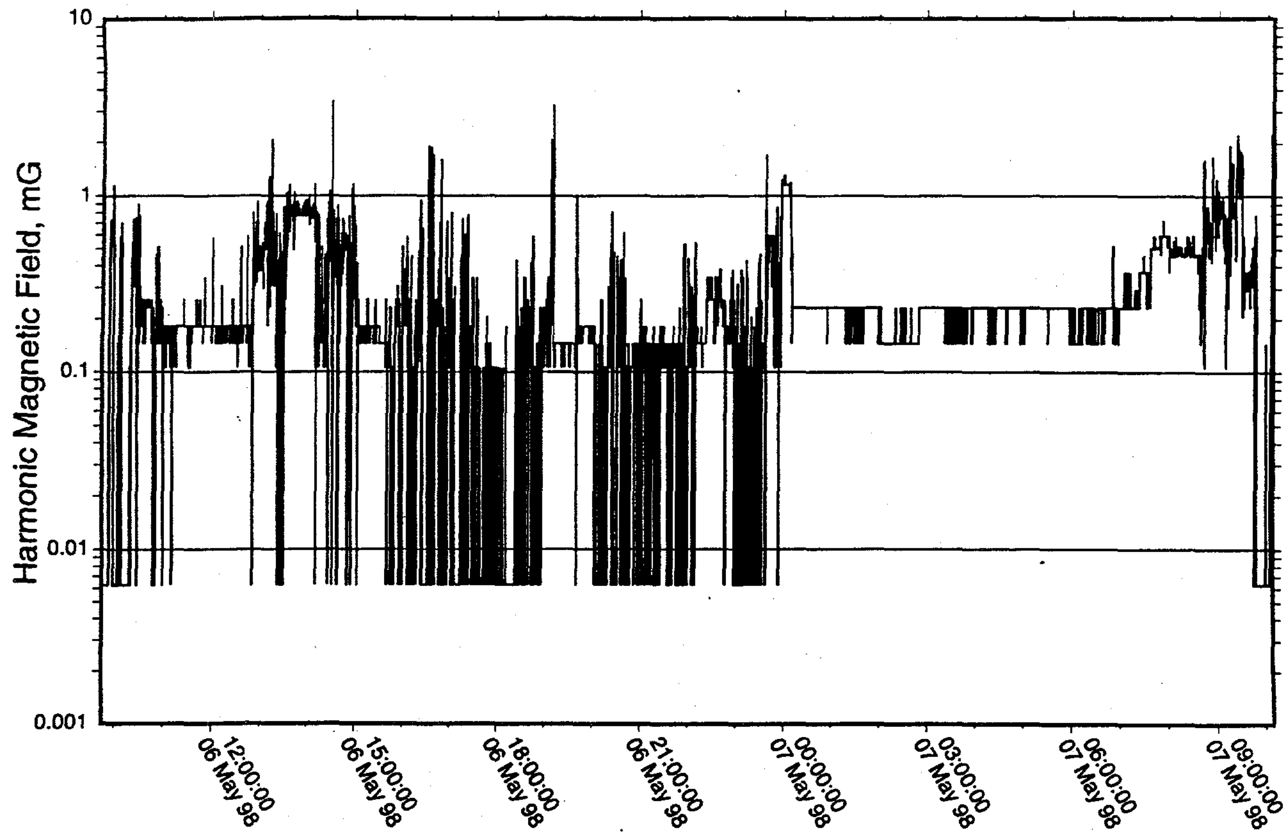


Start date/time	*Location*		*Act*
Tue 05/05 16:38:05	Home	03	19
Tue 05/05 17:15:00	Home	02	100
Tue 05/05 18:15:00	Home	03	185
Tue 05/05 19:00:00	Home	03	204
Tue 05/05 19:45:00	Home	03	142
Tue 05/05 20:00:00	Home	02	29
Tue 05/05 20:30:00	Home	03	71
Tue 05/05 21:00:00	Home	03	76
Tue 05/05 21:30:00	Home	03	174
Wed 05/06 06:00:00	Home	03	77
Wed 05/06 07:00:00	Travel	30	38
Wed 05/06 07:30:00	Work	31	11
Wed 05/06 15:30:00	Travel	30	40
Wed 05/06 16:00:00	Home	02	29
Wed 05/06 16:21:20	End of data		

Harmonic Magnetic Field Measurements: Subject No. 4

RAPID7

Unshaded periods include worn measurements

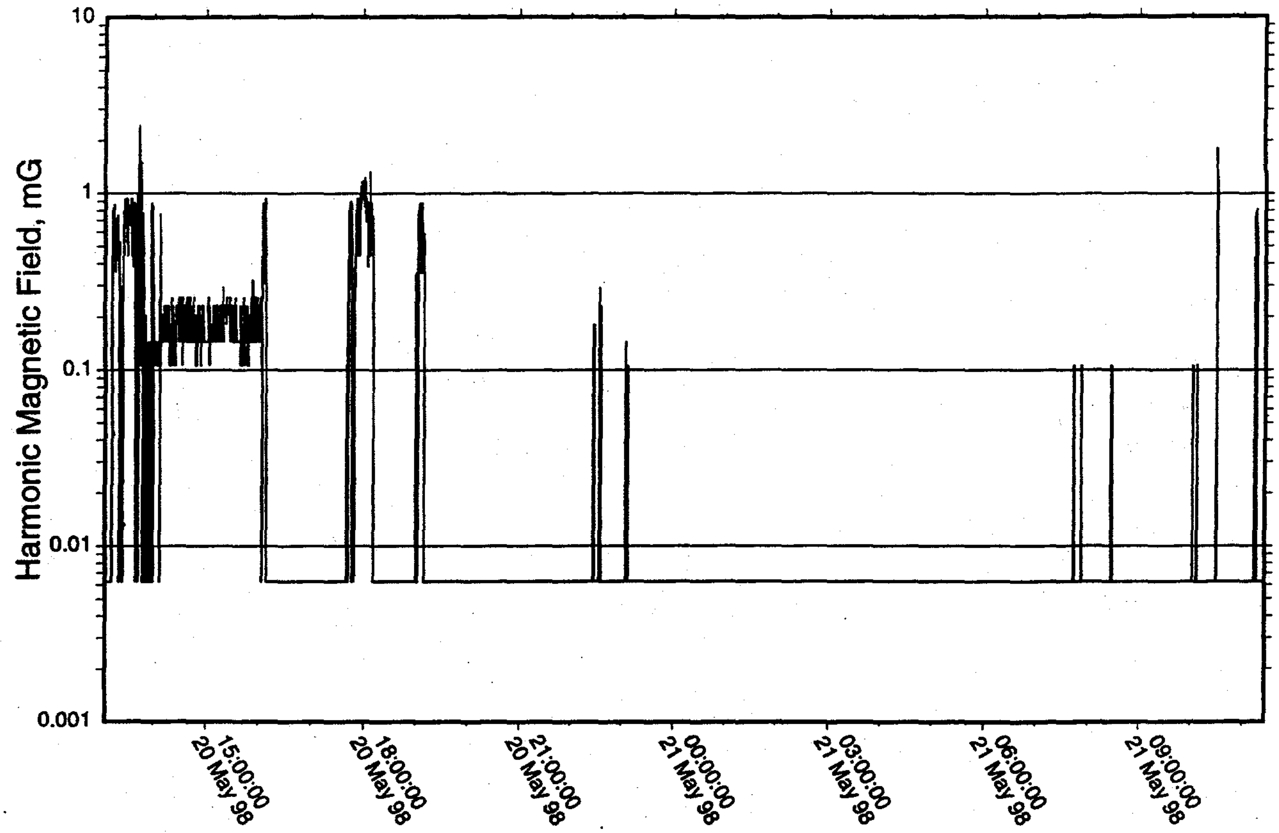


Start date/time	*Location*		*Act*
Wed 05/06 09:44:16	Other	11	207
Wed 05/06 09:50:01	Travel	30	37
Wed 05/06 10:00:01	Other	10	34
Wed 05/06 10:15:01	Travel	30	39
Wed 05/06 10:25:01	Home	03	151
Wed 05/06 10:45:01	Home	03	237
Wed 05/06 12:45:01	Travel	30	131
Wed 05/06 13:15:01	Travel	30	39
Wed 05/06 13:25:01	Home	02	117
Wed 05/06 13:50:01	Home	03	237
Wed 05/06 14:10:01	Home	03	151
Wed 05/06 14:40:01	Travel	30	115
Wed 05/06 14:50:01	Work	31	11
Wed 05/06 23:35:01	Travel	30	40
Wed 05/06 23:50:01	Home	03	76
Thu 05/07 00:00:01	Home	03	145
Thu 05/07 00:10:01	Home	03	76
Thu 05/07 00:45:01	Home	03	174
Thu 05/07 08:30:01	Home	03	81
Thu 05/07 08:40:01	Home	02	75
Thu 05/07 09:15:01	Home	03	22
Thu 05/07 10:08:21	End of data		

Harmonic Magnetic Field Measurements: Subject No. 5

RAPID7

Unshaded periods include worn measurements

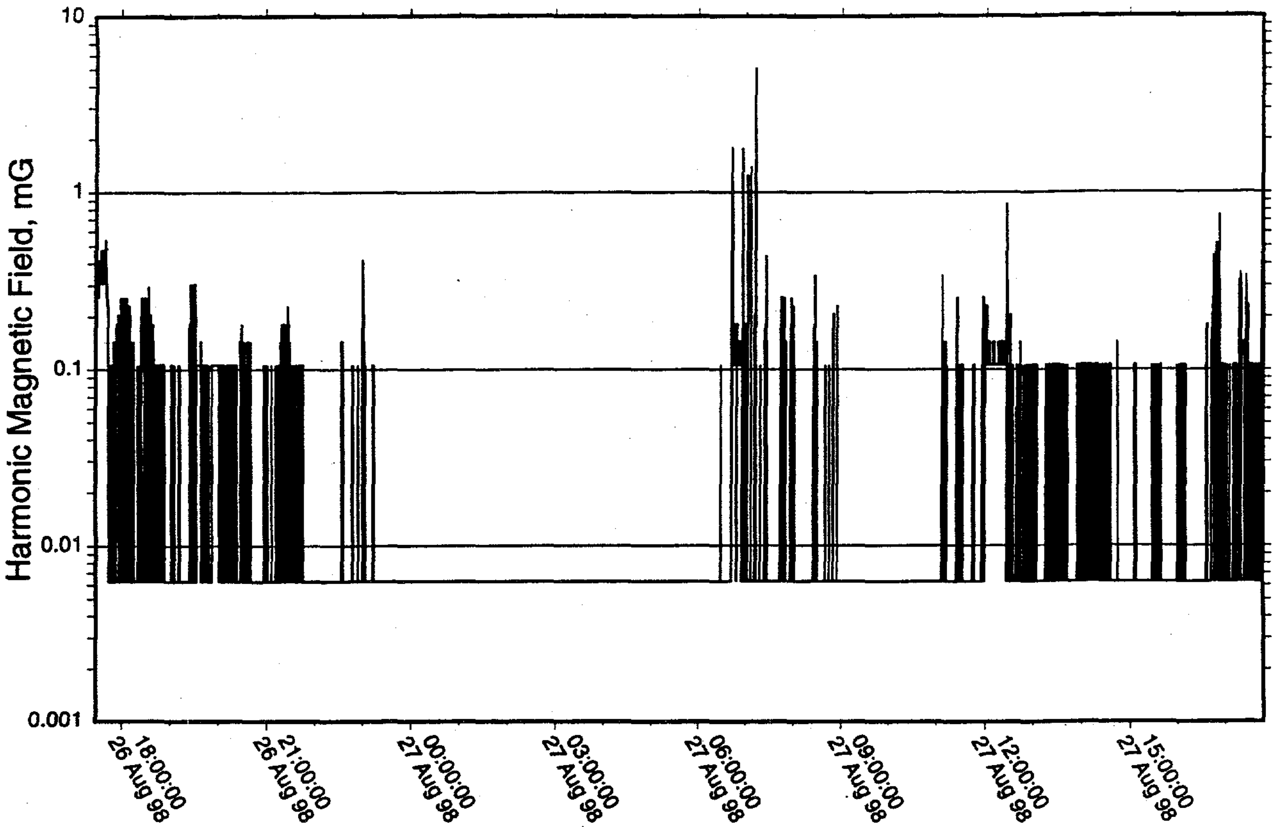


Start date/time	*Location*		*Act*
Wed 05/20 13:05:12	Other	09	184
Wed 05/20 13:50:02	Work	31	1
Wed 05/20 16:00:02	School	07	17
Wed 05/20 17:30:02	Travel	30	50
Wed 05/20 18:00:02	Other	11	133
Wed 05/20 18:45:02	Travel	30	39
Wed 05/20 19:00:02	Home	03	165
Wed 05/20 23:00:02	Home	03	174
Thu 05/21 07:00:02	Home	03	129
Thu 05/21 11:25:32	End of data		

Harmonic Magnetic Field Measurements: Subject No. 6

Unshaded periods include worn measurements

RAPID7

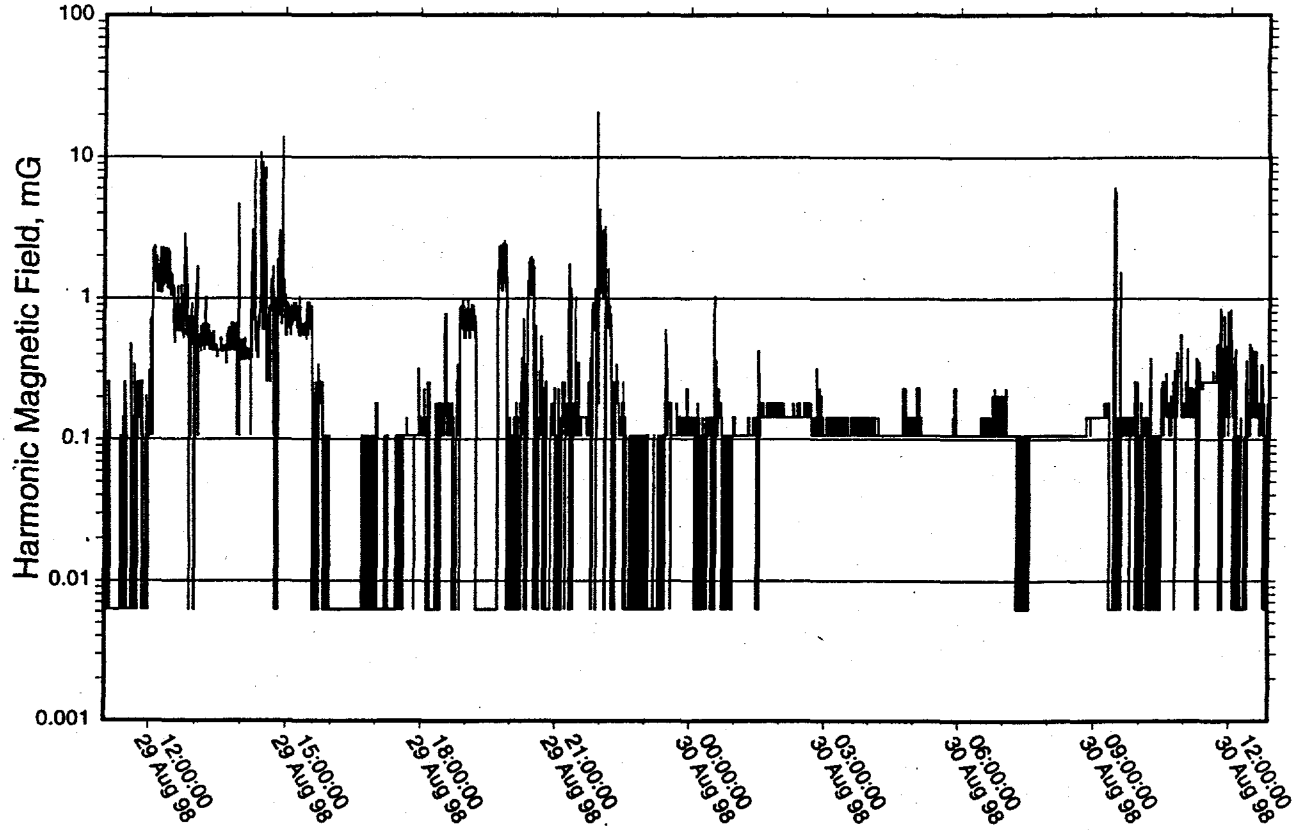


Start date/time	*Location*	*Act*
Wed 08/26 17:28:18	Home 03	175
Wed 08/26 18:00:03	Home 03	219
Wed 08/26 23:10:03	Home 03	174
Thu 08/27 06:30:03	Home 02	136
Thu 08/27 07:45:03	Home 03	226
Thu 08/27 11:10:03	Home 03	173
Thu 08/27 11:45:03	Home 02	69
Thu 08/27 12:30:03	Home 03	220
Thu 08/27 14:30:03	Home 03	128
Thu 08/27 16:30:03	Home 03	108
Thu 08/27 17:47:48	End of data	

Harmonic Magnetic Field Measurements: Subject No. 7

RAPID7

Unshaded periods include worn measurements

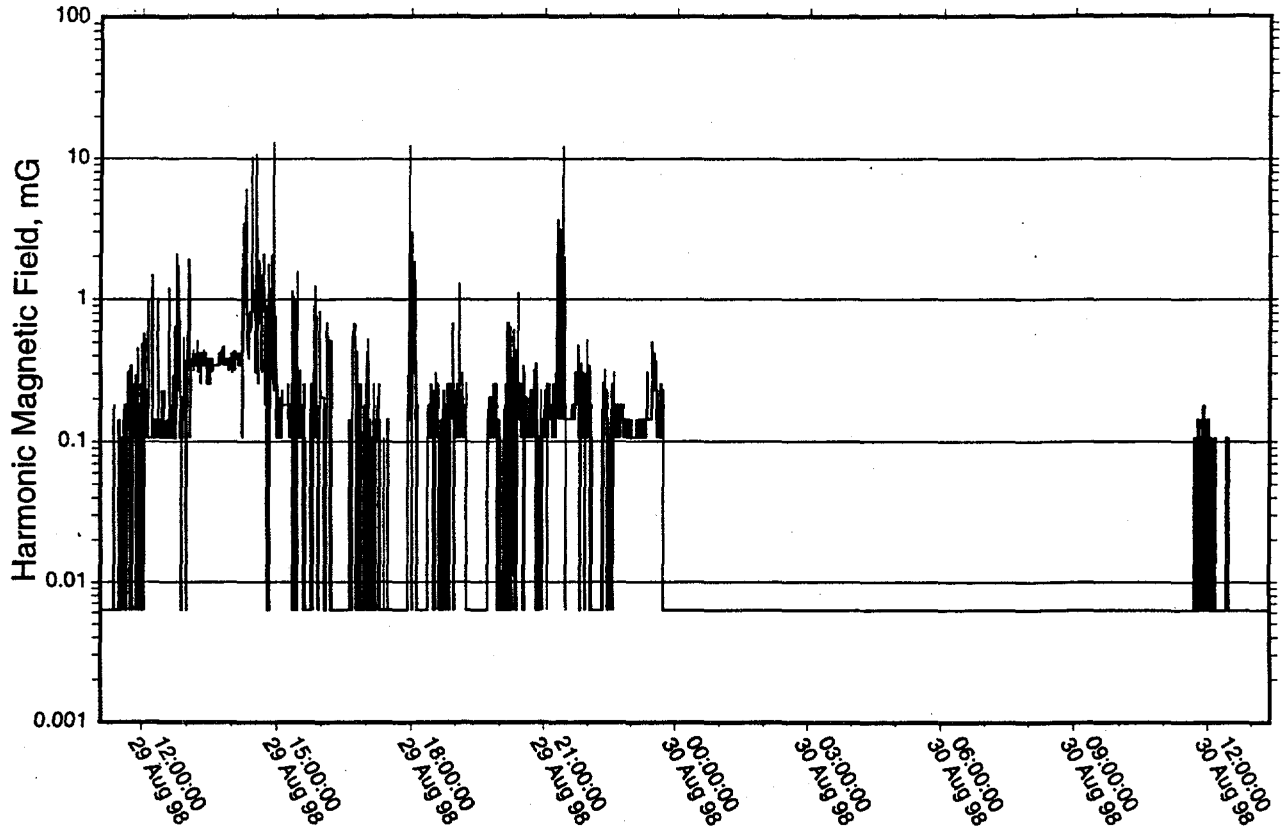


Start date/time	*Location*		*Act*
Sat 08/29 11:01:34	Home	02	114
Sat 08/29 11:45:04	Travel	30	63
Sat 08/29 12:30:04	Other	24	12
Sat 08/29 14:00:04	Travel	30	210
Sat 08/29 14:45:04	Travel	30	39
Sat 08/29 15:15:04	Home	03	188
Sat 08/29 17:00:04	Home	03	24
Sat 08/29 18:00:04	Travel	30	61
Sat 08/29 19:30:04	Other	21	214
Sat 08/29 20:15:04	Travel	30	39
Sat 08/29 21:45:04	Travel	30	66
Sat 08/29 21:55:04	Other	27	10
Sat 08/29 22:15:04	Travel	30	39
Sat 08/29 22:25:04	Home	03	223
Sun 08/30 01:00:04	Home	03	174
Sun 08/30 08:30:04	Home	02	86
Sun 08/30 09:45:04	Home	03	203
Sun 08/30 10:30:04	Home	03	96
Sun 08/30 12:51:54	End of data		

Harmonic Magnetic Field Measurements: Subject No. 8

RAPID7

Unshaded periods include worn measurements

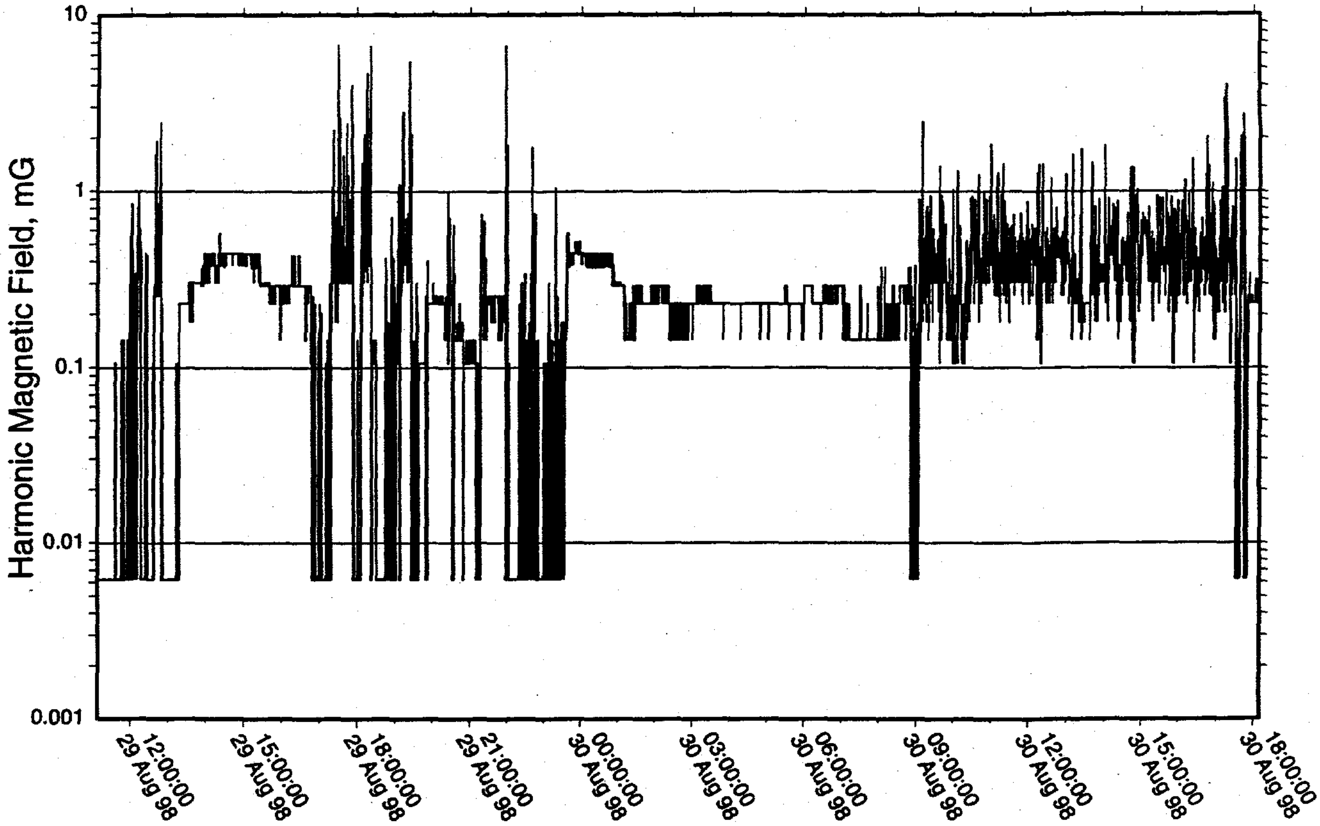


Start date/time	*Location*		*Act*
Sat 08/29 11:04:59	Home	02	114
Sat 08/29 12:30:04	Travel	30	44
Sat 08/29 13:15:04	Other	24	93
Sat 08/29 14:30:04	Other	06	166
Sat 08/29 14:50:04	Travel	30	47
Sat 08/29 15:15:04	Other	27	167
Sat 08/29 15:25:04	Travel	30	39
Sat 08/29 15:40:04	Travel	30	59
Sat 08/29 16:10:04	Other	20	206
Sat 08/29 16:40:04	Travel	30	39
Sat 08/29 16:45:04	Home	03	102
Sat 08/29 18:00:04	Home	03	25
Sat 08/29 18:20:04	Travel	30	60
Sat 08/29 18:45:04	Travel	30	61
Sat 08/29 19:00:04	Other	21	214
Sat 08/29 19:40:04	Travel	30	52
Sat 08/29 19:50:04	Other	27	170
Sat 08/29 20:30:04	Travel	30	39
Sat 08/29 20:40:04	Home	02	28
Sat 08/29 21:20:04	Home	03	15
Sat 08/29 22:10:04	Home	03	217
Sun 08/30 01:00:04	Home	03	174
Sun 08/30 13:24:49	End of data		

Harmonic Magnetic Field Measurements: Subject No. 9

RAPID7

Unshaded periods include worn measurements

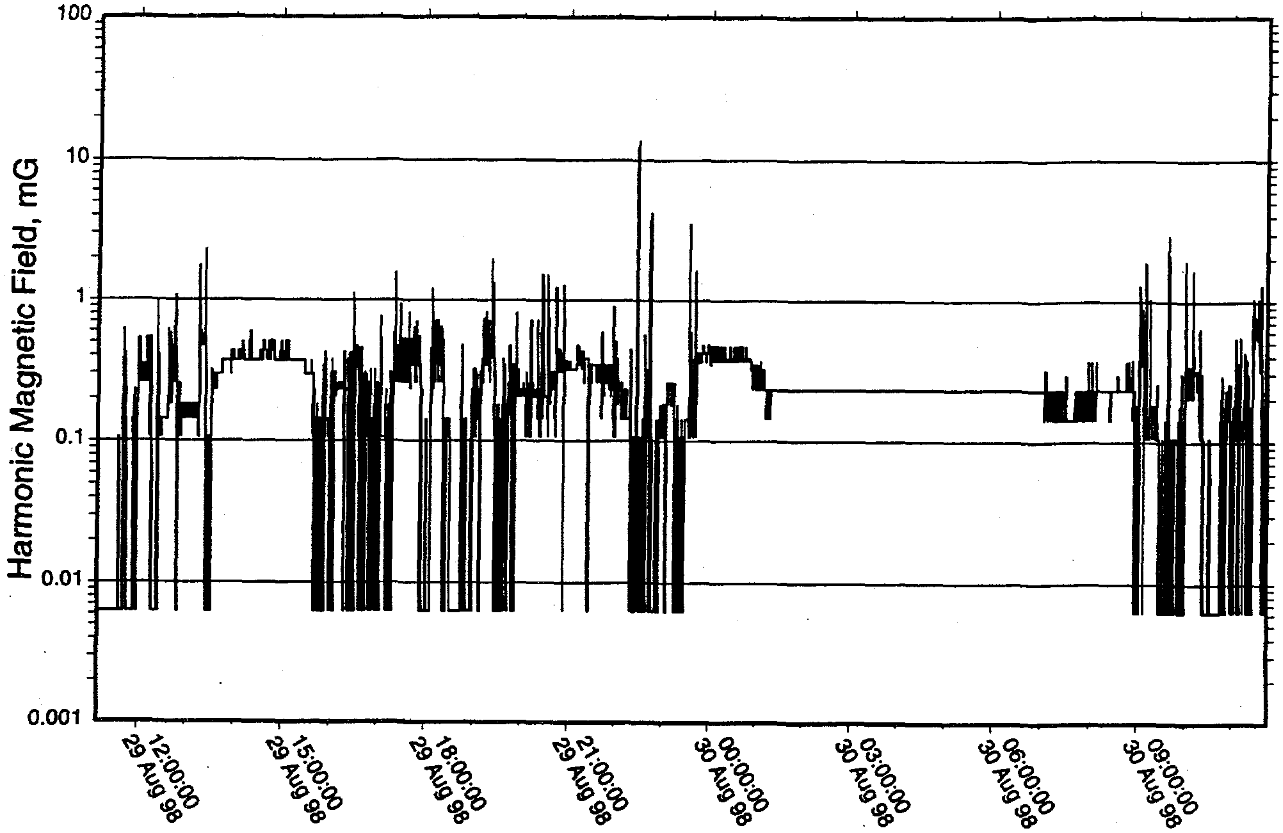


Start date/time	*Location*		*Act*
Sat 08/29 11:08:23	Other	18	114
Sat 08/29 11:30:03	Travel	30	54
Sat 08/29 11:35:03	Other	27	171
Sat 08/29 11:45:03	Travel	30	62
Sat 08/29 12:00:03	Other	24	113
Sat 08/29 12:15:03	Travel	30	39
Sat 08/29 12:30:03	Home	03	70
Sat 08/29 16:30:03	Home	03	78
Sat 08/29 17:30:03	Travel	30	41
Sat 08/29 18:10:03	Other	29	80
Sat 08/29 18:25:03	Travel	30	48
Sat 08/29 18:40:03	Other	27	168
Sat 08/29 19:00:03	Travel	30	39
Sat 08/29 19:15:03	Home	03	150
Sat 08/29 19:35:03	Home	02	103
Sat 08/29 19:55:03	Home	03	221
Sat 08/29 20:10:03	Home	02	36
Sat 08/29 20:45:03	Home	03	222
Sat 08/29 23:35:03	Home	03	174
Sun 08/30 08:30:03	Home	03	77
Sun 08/30 08:55:03	Travel	30	67
Sun 08/30 09:00:03	Work	31	11
Sun 08/30 17:00:03	Other	27	209
Sun 08/30 17:10:03	Travel	30	39
Sun 08/30 17:35:03	Home	03	152
Sun 08/30 18:09:13	End of data		

Harmonic Magnetic Field Measurements: Subject No. 10

RAPID7

Unshaded periods include worn measurements

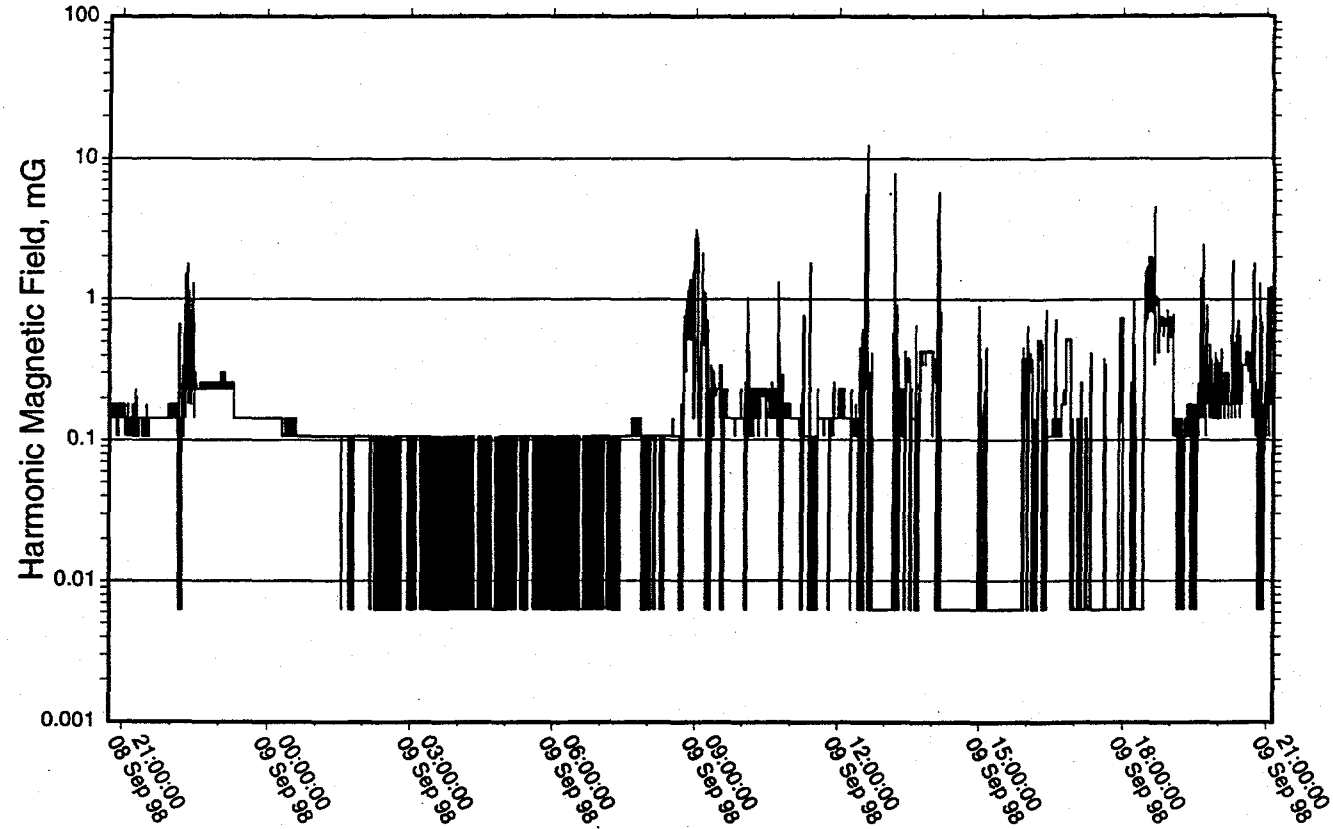


Start date/time	*Location*		*Act*
Sat 08/29 11:10:34	Other	12	114
Sat 08/29 11:45:04	Travel	30	235
Sat 08/29 11:55:04	Travel	30	62
Sat 08/29 12:00:04	Other	24	126
Sat 08/29 12:20:04	Travel	30	39
Sat 08/29 12:30:04	Home	03	164
Sat 08/29 14:30:04	Home	03	147
Sat 08/29 16:00:04	Home	03	240
Sat 08/29 16:30:04	Travel	30	41
Sat 08/29 17:00:04	Other	29	230
Sat 08/29 17:20:04	Travel	30	48
Sat 08/29 17:40:04	Other	27	168
Sat 08/29 19:00:04	Travel	30	39
Sat 08/29 19:30:04	Home	02	6
Sat 08/29 19:40:04	Home	03	228
Sat 08/29 20:10:04	Home	03	239
Sat 08/29 21:10:04	Home	03	101
Sat 08/29 22:10:04	Home	02	229
Sat 08/29 23:30:04	Home	03	221
Sat 08/29 23:50:04	Home	03	174
Sun 08/30 08:50:04	Home	02	73
Sun 08/30 09:20:04	Home	03	105
Sun 08/30 10:20:04	Home	03	190
Sun 08/30 11:00:04	Other	19	211
Sun 08/30 11:20:04	Travel	30	51
Sun 08/30 11:46:04	End of data		

Harmonic Magnetic Field Measurements: Subject No. 11

RAPID7

Unshaded periods include worn measurements

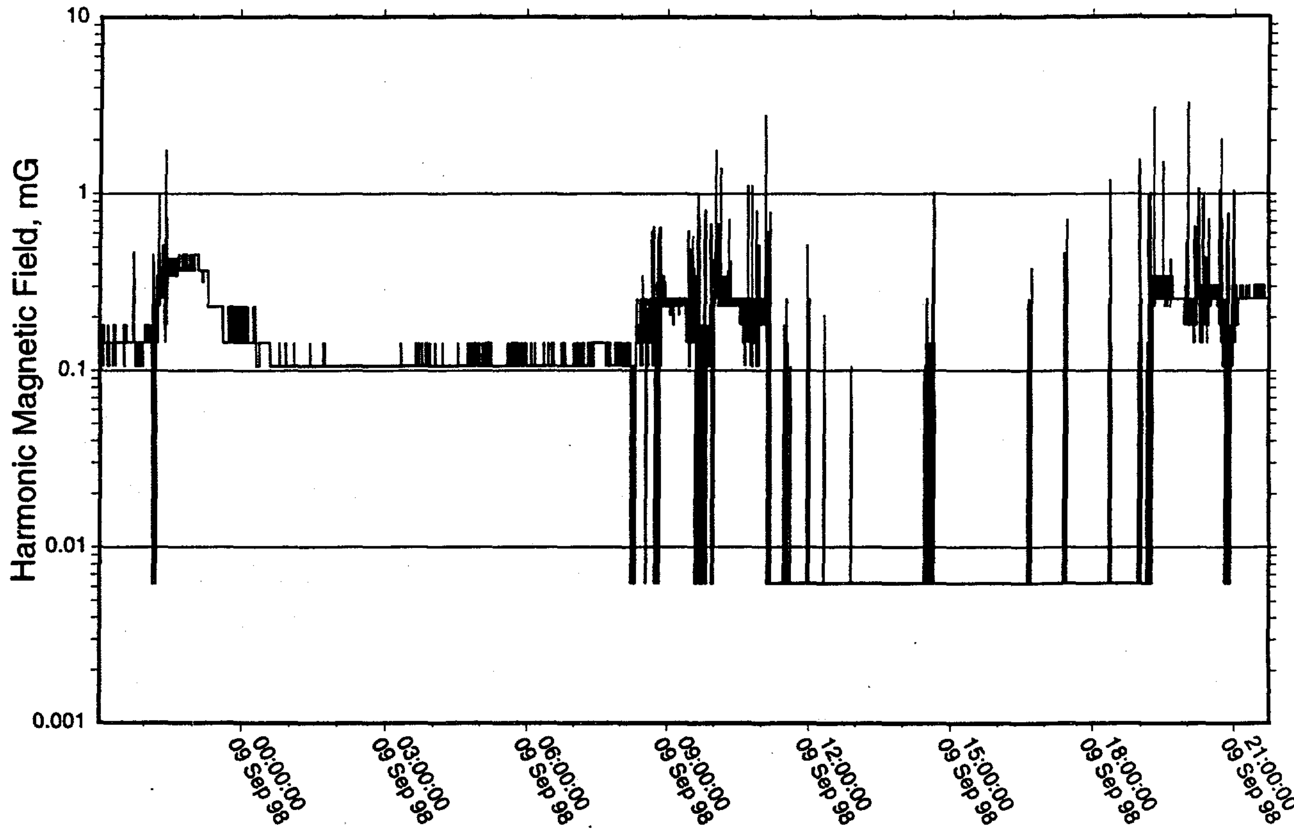


Start date/time	*Location*		*Act*
Tue 09/08 20:44:50	Other	24	94
Tue 09/08 22:15:00	Travel	30	213
Tue 09/08 22:30:00	Home	03	174
Wed 09/09 07:15:00	Home	03	85
Wed 09/09 08:41:00	Travel	30	67
Wed 09/09 08:57:00	Other	23	179
Wed 09/09 09:13:00	Travel	30	67
Wed 09/09 09:23:00	Work	31	11
Wed 09/09 18:27:00	Travel	30	39
Wed 09/09 18:40:00	Home	03	147
Wed 09/09 19:30:00	Home	02	123
Wed 09/09 20:35:00	Travel	30	225
Wed 09/09 21:08:35	End of data		

Harmonic Magnetic Field Measurements: Subject No. 12

RAPID7

Unshaded periods include worn measurements

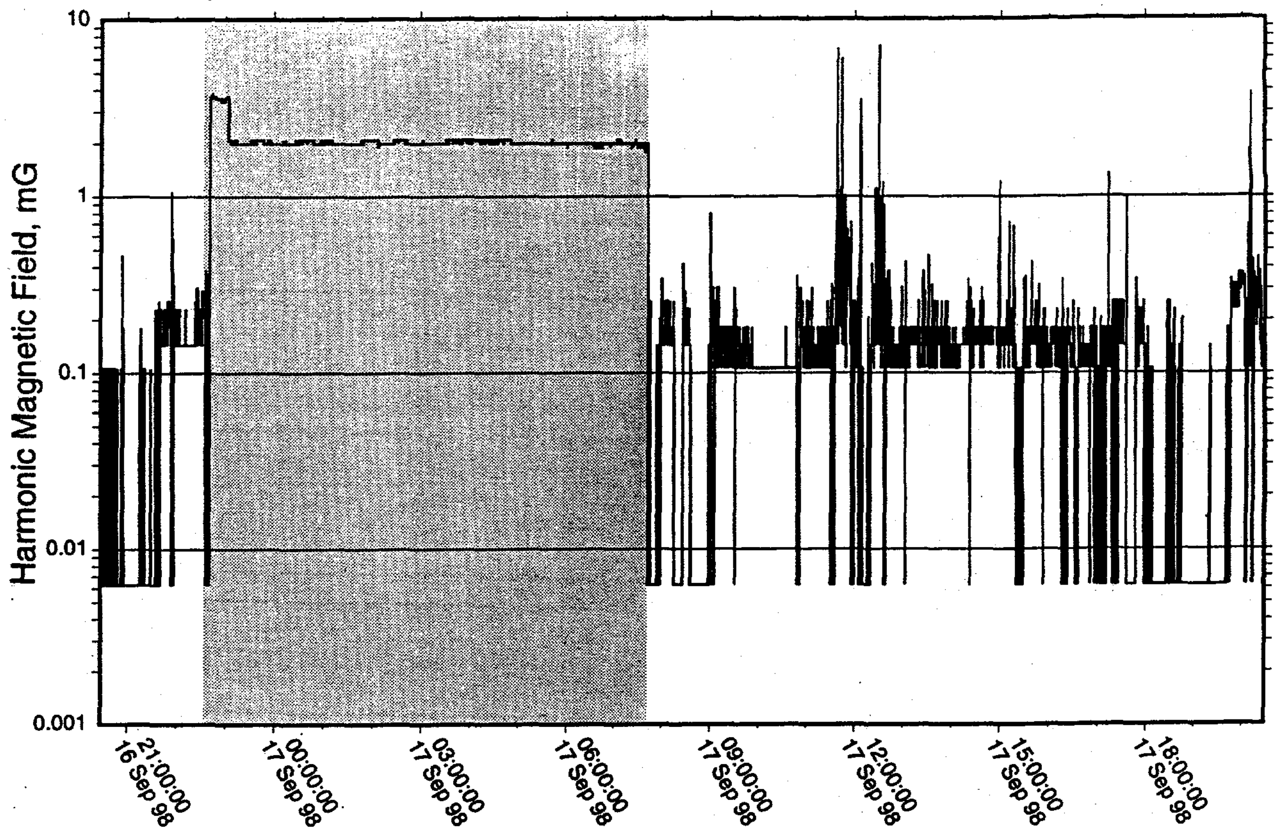


Start date/time	*Location*		*Act*
Tue 09/08 21:03:39	Other	24	31
Tue 09/08 22:00:04	Travel	30	213
Tue 09/08 22:30:04	Home	03	174
Wed 09/09 07:00:04	Home	03	85
Wed 09/09 08:30:04	Travel	30	216
Wed 09/09 08:40:04	Other	24	14
Wed 09/09 09:30:04	Travel	30	213
Wed 09/09 09:40:04	Travel	30	67
Wed 09/09 11:00:04	Work	31	238
Wed 09/09 19:15:04	Travel	30	39
Wed 09/09 20:10:04	Home	02	15
Wed 09/09 20:30:04	Travel	30	225
Wed 09/09 21:44:39	End of data		

Harmonic Magnetic Field Measurements: Subject No. 13

RAPID7

Unshaded periods include worn measurements

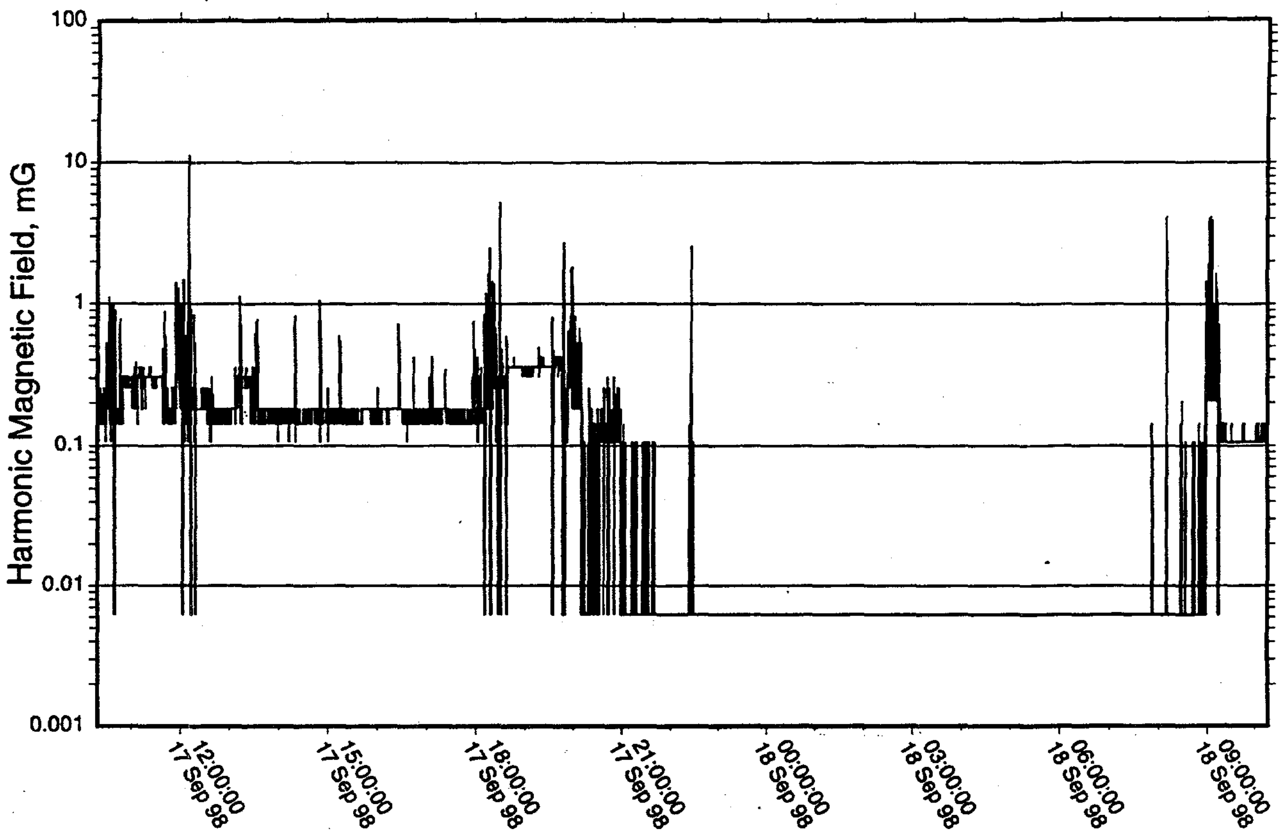


Start date/time	*Location*		*Act*
Wed 09/16 20:27:46	**Home**	**03**	**178**
Wed 09/16 21:34:01	**Home**	**03**	**218**
Wed 09/16 22:33:01	Excluded		174
Thu 09/17 07:42:01	**Home**	**02**	**85**
Thu 09/17 07:55:01	**Travel**	**30**	**56**
Thu 09/17 08:10:01	**Other**	**21**	**212**
Thu 09/17 08:30:01	**Travel**	**30**	**67**
Thu 09/17 09:04:01	**Work**	**31**	**241**
Thu 09/17 11:27:01	**Travel**	**30**	**107**
Thu 09/17 12:08:01	**Home**	**02**	**5**
Thu 09/17 12:17:01	**Travel**	**30**	**67**
Thu 09/17 12:36:01	**Work**	**31**	**241**
Thu 09/17 17:23:01	**Travel**	**30**	**56**
Thu 09/17 17:30:01	**Other**	**21**	**212**
Thu 09/17 17:50:01	**Travel**	**30**	**39**
Thu 09/17 17:58:01	**Home**	**02**	**5**
Thu 09/17 20:28:36	**End of data**		

Harmonic Magnetic Field Measurements: Subject No. 14

RAPID7

Unshaded periods include worn measurements

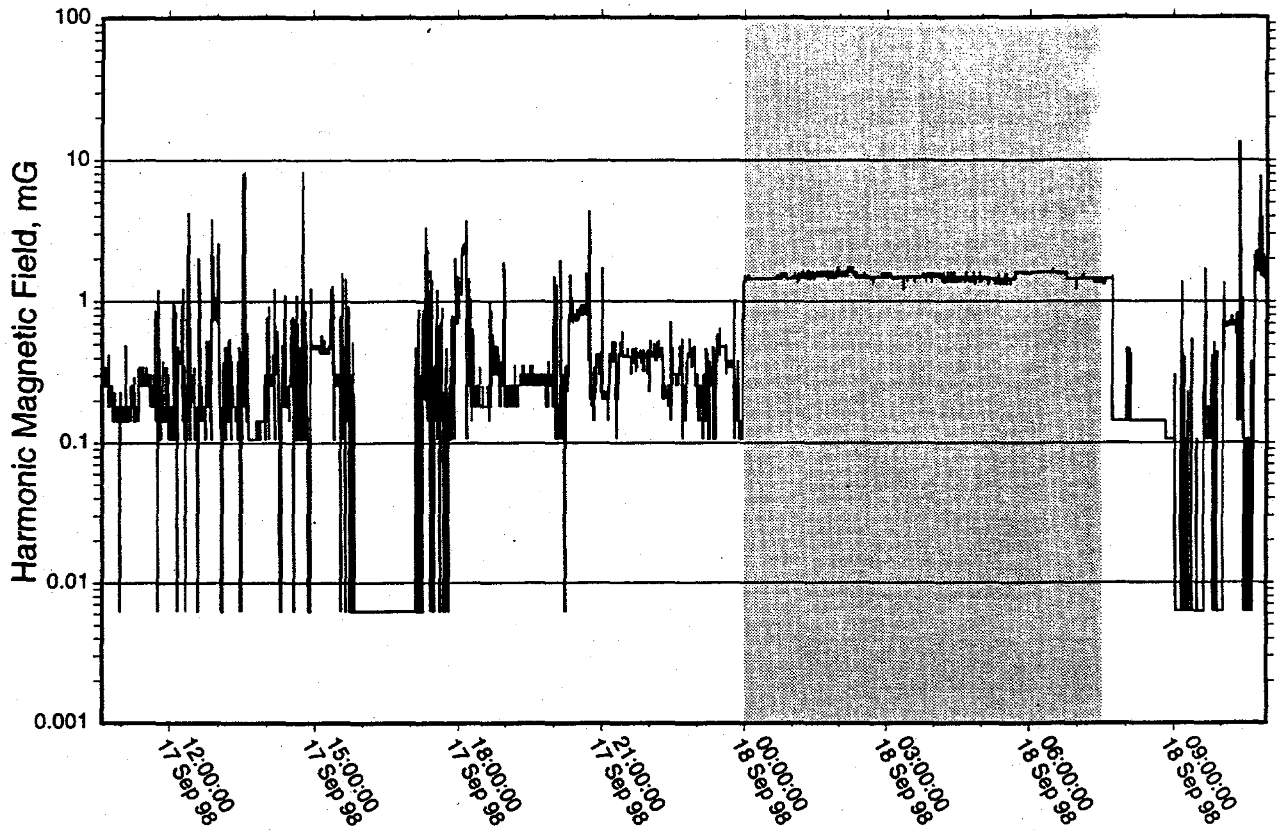


Start date/time			Location		Act
Thu	09/17	10:19:36	Work	31	178
Thu	09/17	10:29:01	Work	31	241
Thu	09/17	11:58:01	Travel	30	215
Thu	09/17	12:15:01	Work	31	241
Thu	09/17	18:05:01	Travel	30	49
Thu	09/17	18:35:01	Other	14	72
Thu	09/17	19:51:01	Travel	30	39
Thu	09/17	20:01:01	Home	03	149
Thu	09/17	20:18:01	Home	02	27
Thu	09/17	20:58:01	Home	03	91
Thu	09/17	21:15:01	Home	03	23
Thu	09/17	21:18:01	Home	03	219
Thu	09/17	22:19:01	Home	03	135
Thu	09/17	22:30:01	Home	03	174
Fri	09/18	07:45:01	Home	03	90
Fri	09/18	08:11:01	Home	03	85
Fri	09/18	08:40:01	Home	02	89
Fri	09/18	08:58:01	Travel	30	67
Fri	09/18	09:08:01	Work	31	241
Fri	09/18	10:17:31	End of data		

Harmonic Magnetic Field Measurements: Subject No. 15

RAPID7

Unshaded periods include worn measurements



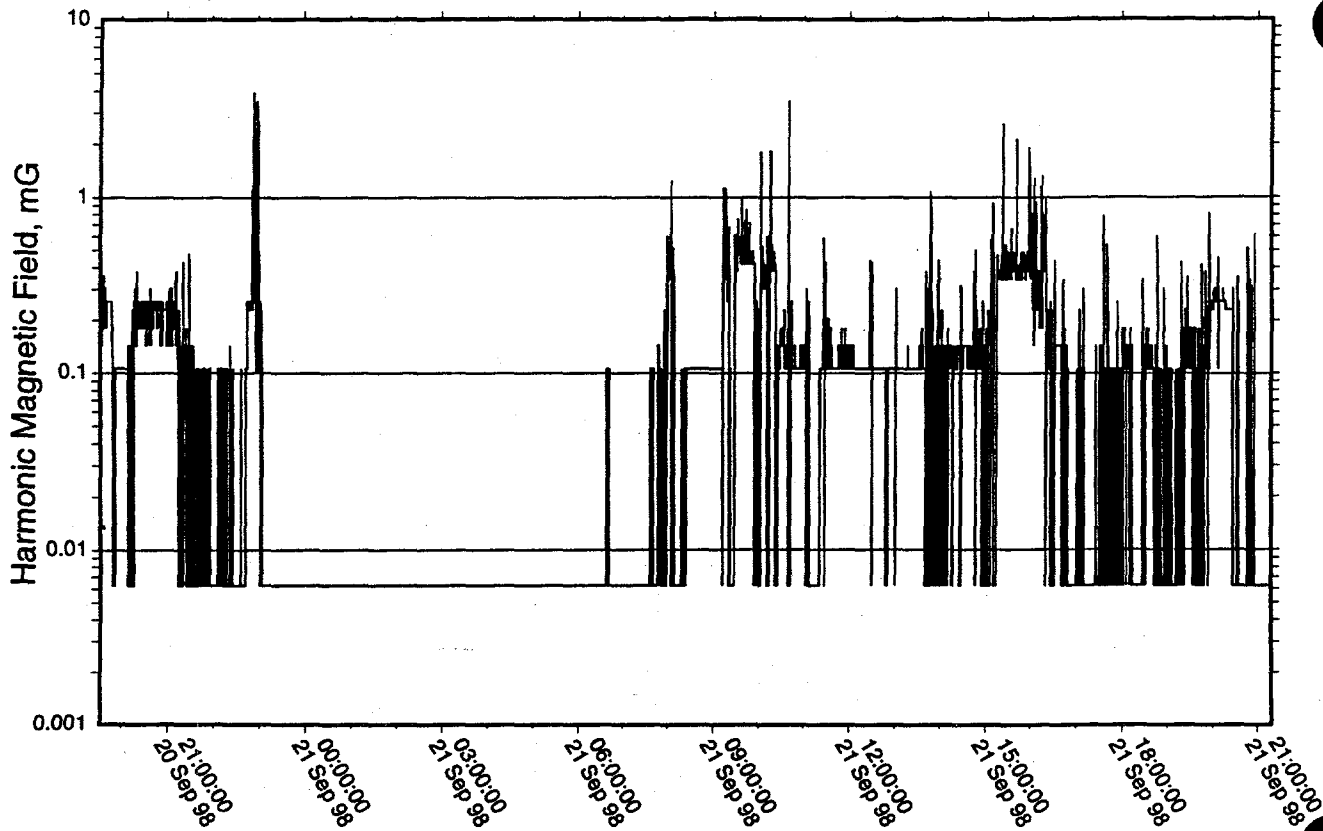
Start date/time	*Location*	*Act*
Thu 09/17 10:36:28	**Work 31**	**178**
Thu 09/17 20:30:03	**Travel 30**	**162**
Thu 09/17 21:00:03	**Home 03**	**92**
Fri 09/18 00:00:03	Excluded	174
Fri 09/18 05:50:03	Excluded	163
Fri 09/18 07:30:03	**Work 31**	**242**
Fri 09/18 09:30:03	**Work 31**	**140**
Fri 09/18 10:57:23	**End of data**	

EPRI RAPID7 /rapid/rapid/data/R7-15-00.bts

Harmonic Magnetic Field Measurements: Subject No. 16

RAPID7

Unshaded periods include worn measurements

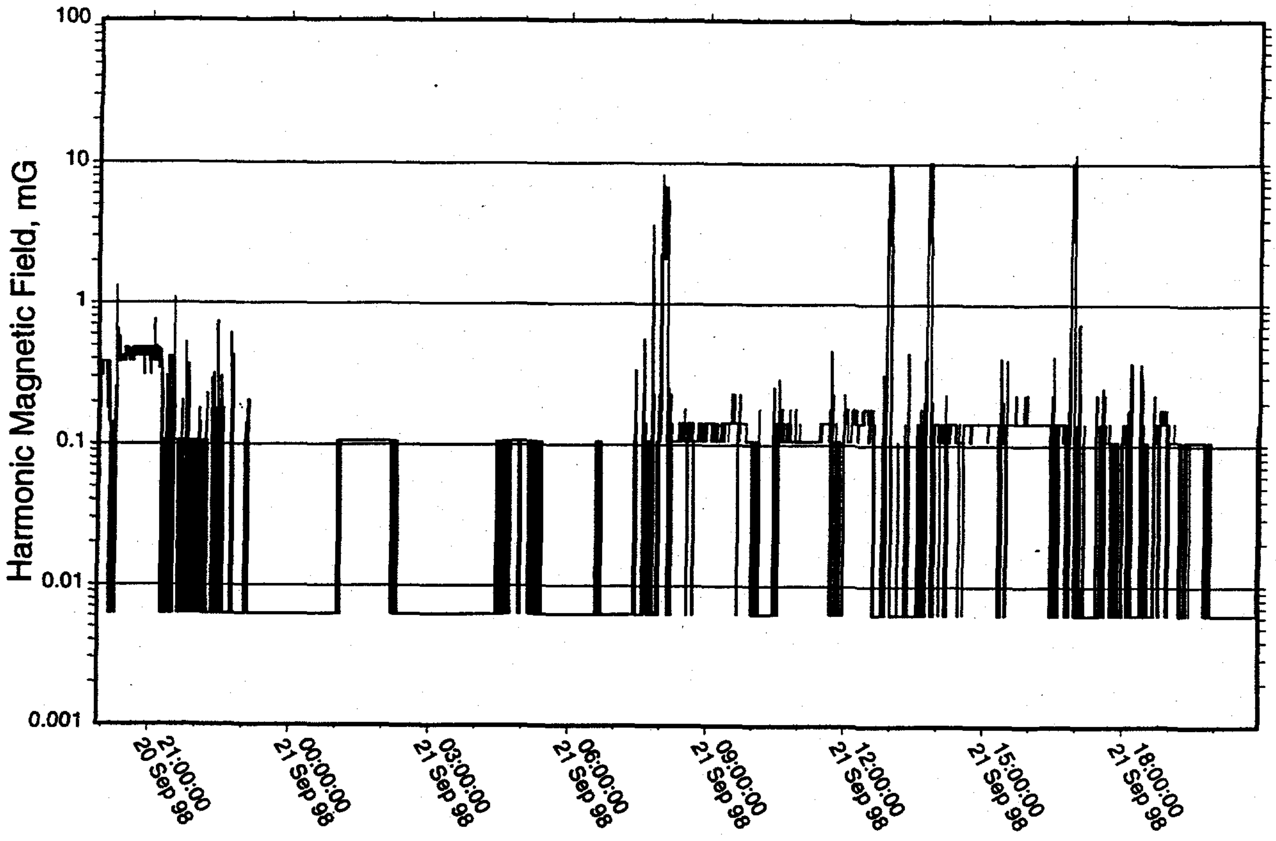


Start date/time	*Location*		*Act*
Sun 09/20 19:33:27	Other	15	18
Sun 09/20 20:07:02	Travel	30	39
Sun 09/20 21:15:02	Home	02	3
Sun 09/20 22:20:02	Home	03	141
Sun 09/20 23:06:02	Home	03	174
Mon 09/21 07:33:02	Home	03	87
Mon 09/21 07:57:02	Travel	30	53
Mon 09/21 08:04:02	Other	14	246
Mon 09/21 09:12:02	Travel	30	45
Mon 09/21 10:05:02	Other	08	181
Mon 09/21 10:10:02	Travel	30	52
Mon 09/21 10:15:02	Other	13	180
Mon 09/21 10:18:02	Travel	30	67
Mon 09/21 10:25:02	Work	31	241
Mon 09/21 15:03:02	Travel	30	64
Mon 09/21 16:01:02	Travel	30	42
Mon 09/21 16:10:02	Other	04	106
Mon 09/21 16:15:02	Travel	30	39
Mon 09/21 16:20:02	Home	03	149
Mon 09/21 17:01:02	Travel	30	211
Mon 09/21 17:32:02	Home	03	224
Mon 09/21 21:00:02	Home	03	26
Mon 09/21 21:19:07	End of data		

Harmonic Magnetic Field Measurements: Subject No. 17

RAPID7

Unshaded periods include worn measurements

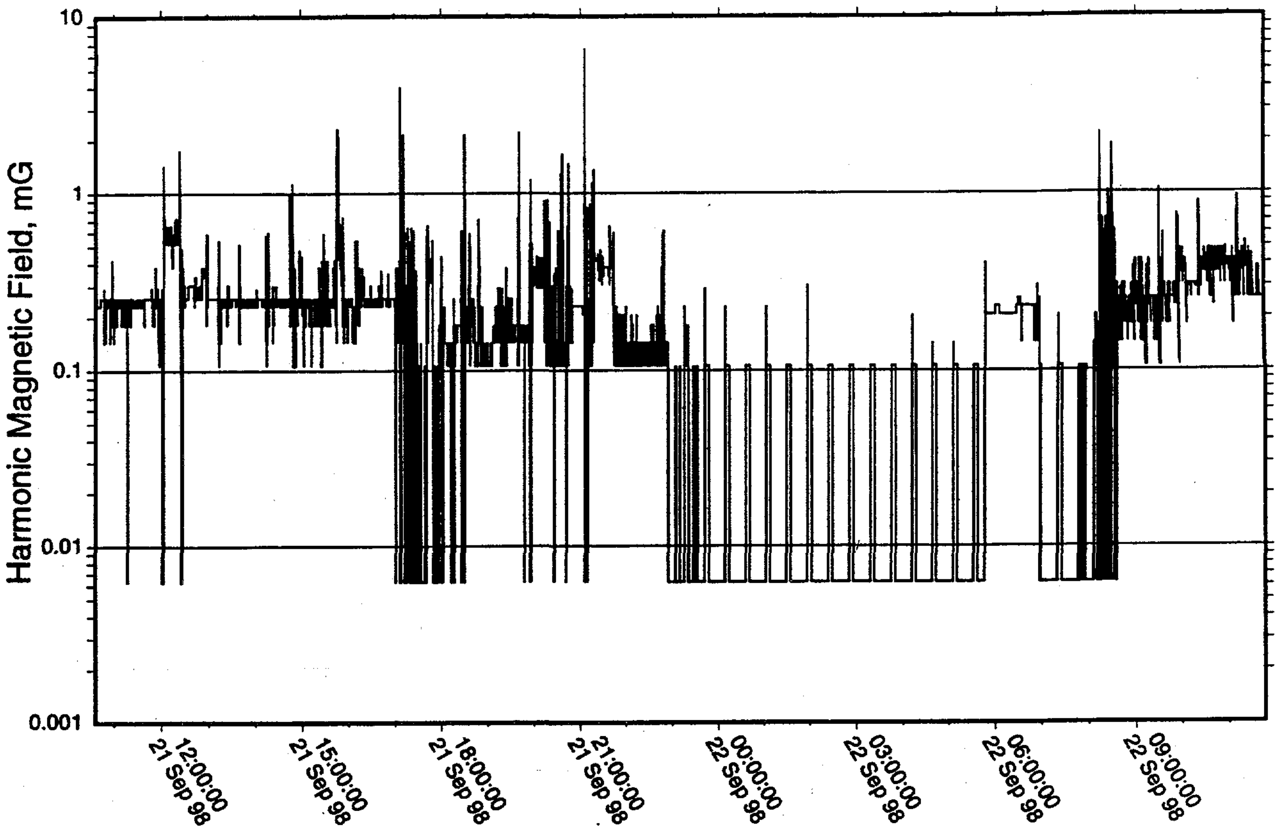


Start date/time	*Location*		*Act*
Sun 09/20 19:54:30	Other	15	18
Sun 09/20 20:15:00	Travel	30	39
Sun 09/20 21:20:00	Home	03	182
Sun 09/20 22:30:00	Home	03	20
Sun 09/20 23:00:00	Home	03	174
Mon 09/21 07:10:00	Travel	30	208
Mon 09/21 07:30:00	Home	02	35
Mon 09/21 07:45:00	Travel	30	159
Mon 09/21 08:00:00	Work	31	236
Mon 09/21 12:44:00	Travel	30	157
Mon 09/21 12:55:00	Home	02	16
Mon 09/21 13:45:00	Travel	30	159
Mon 09/21 13:55:00	Work	31	236
Mon 09/21 15:15:00	Work	31	119
Mon 09/21 15:17:00	Work	31	124
Mon 09/21 16:39:00	Travel	30	156
Mon 09/21 16:50:00	Travel	30	211
Mon 09/21 17:30:00	Home	03	5
Mon 09/21 18:15:00	Travel	30	57
Mon 09/21 18:20:00	Other	13	111
Mon 09/21 18:22:00	Travel	30	39
Mon 09/21 18:23:00	Home	03	183
Mon 09/21 20:56:00	End of data		

Harmonic Magnetic Field Measurements: Subject No. 18

RAPID7

Unshaded periods include worn measurements

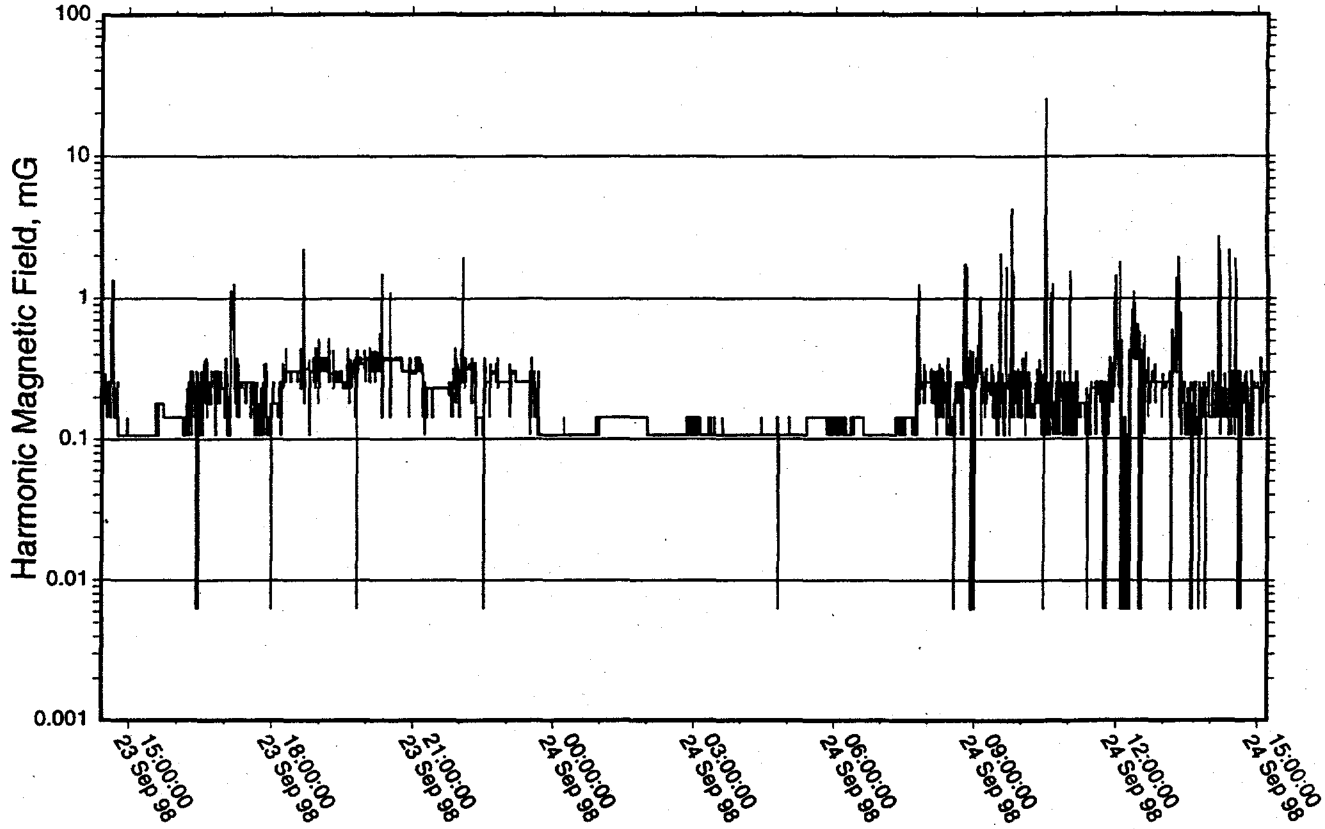


Start date/time			*Location*		*Act*
Mon	09/21	10:36:10	Work	31	18
Mon	09/21	10:45:00	Work	31	176
Mon	09/21	12:00:00	Travel	30	231
Mon	09/21	12:05:00	Other	24	13
Mon	09/21	12:30:00	Travel	30	154
Mon	09/21	12:35:00	Work	31	238
Mon	09/21	17:04:00	Travel	30	39
Mon	09/21	17:29:00	Home	02	28
Mon	09/21	18:00:00	Home	03	239
Mon	09/21	19:39:00	Home	03	146
Mon	09/21	20:19:00	Home	02	122
Mon	09/21	20:43:00	Home	03	143
Mon	09/21	21:07:00	Home	03	84
Mon	09/21	21:17:00	Home	03	144
Mon	09/21	21:43:00	Home	03	219
Mon	09/21	22:47:00	Home	03	227
Tue	09/22	07:46:00	Home	03	83
Tue	09/22	08:05:00	Travel	30	67
Tue	09/22	08:37:00	Work	31	2
Tue	09/22	11:47:20	End of data		

Harmonic Magnetic Field Measurements: Subject No. 19

RAPID7

Unshaded periods include worn measurements

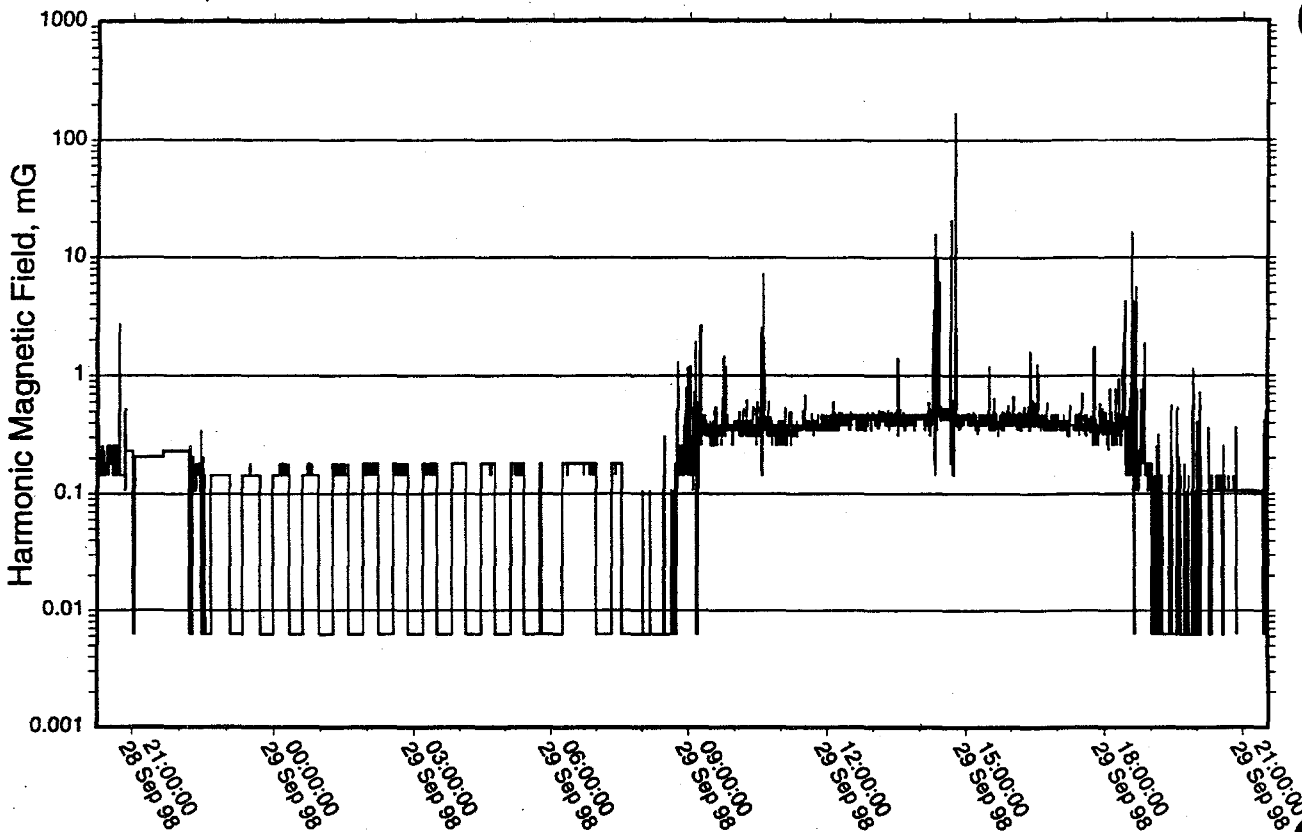


Start date/time	*Location*		*Act*
Wed 09/23 14:26:49	Home	03	18
Wed 09/23 14:45:04	Home	03	186
Wed 09/23 16:07:04	Home	02	148
Wed 09/23 23:30:04	Home	03	174
Thu 09/24 07:30:04	Home	02	118
Thu 09/24 08:45:04	Travel	30	65
Thu 09/24 09:00:04	School	25	9
Thu 09/24 09:05:04	Travel	30	39
Thu 09/24 09:15:04	Home	03	98
Thu 09/24 11:45:04	Travel	30	65
Thu 09/24 12:00:04	School	25	9
Thu 09/24 12:15:04	Travel	30	55
Thu 09/24 12:30:04	Other	24	116
Thu 09/24 13:15:04	Travel	30	39
Thu 09/24 13:30:04	Home	03	98
Thu 09/24 15:12:34	End of data		

Harmonic Magnetic Field Measurements: Subject No. 20

RAPID7

Unshaded periods include worn measurements



Start date/time			*Location*		*Act*
Mon	09/28	20:15:18	Home	03	18
Mon	09/28	22:15:03	Home	03	84
Mon	09/28	22:30:03	Home	03	174
Tue	09/29	07:31:03	Home	03	202
Tue	09/29	07:32:03	Home	03	82
Tue	09/29	08:30:03	Travel	30	43
Tue	09/29	09:05:03	Travel	30	155
Tue	09/29	09:15:03	Work	31	161
Tue	09/29	09:16:03	Work	31	177
Tue	09/29	09:27:03	Work	31	201
Tue	09/29	10:09:03	Work	31	199
Tue	09/29	10:16:03	Work	31	138
Tue	09/29	10:33:03	Work	31	161
Tue	09/29	10:36:03	Work	31	30
Tue	09/29	14:11:03	Work	31	200
Tue	09/29	14:17:03	Work	31	139
Tue	09/29	14:20:03	Work	31	95
Tue	09/29	14:40:03	Work	31	138
Tue	09/29	14:42:03	Work	31	161
Tue	09/29	18:21:03	Work	31	160
Tue	09/29	18:22:03	Work	31	139
Tue	09/29	18:31:03	Travel	30	158
Tue	09/29	18:40:03	Travel	30	39
Tue	09/29	18:59:03	Home	02	74
Tue	09/29	21:33:03	End of data		

APPENDIX D

PILOT STUDY: SUMMARY DATA FILE FIELDS

Key to Summary File for Pilot Study Subjects

Field number	Description	Codes/Units
1	Subject number	
2	Subject age	numeric from 23 to 77
3	Subject sex	1 = female 2 = male
4	Employment	1 = full-time 2 = homemaker 3 = part-time 4 = retired 5 = unemployed
5	Job title	0 = NIL 1 = accounting consultant and bookkeeping 2 = administrative assistant 3 = associate accountant 4 = business manager 5 = buyer 6 = computer scientist 7 = computer scientist group leader 8 = environmental planner; conduct studies of environmental effects of projects (e.g. electrical facilities, forest management, urban landscape) 9 = field director 10 = fish biologist 11 = library assistant 12 = mechanic, acting mechanics supervisor 13 = office manager 14 = owner 15 = production manager; supervise personnel who produce document binding equipment 16 = salesperson 17 = systems engineer
6	Construction year	1 = 1965 or after 2 = before 1965
7	Square footage	1 = 1800+ 2 = <1800
8	Outlets	1 = 3-prong 2 = both
9	Water	1 = private well 2 = water system or shared well
10	School building	0 = NIL 1 = commercial building

Field number	Description	Codes/Units
11	Residence type	1 = duplex or other multiple family unit 2 = other) triplex 3 = single family detached house
12	Transmission present	1 = no 2 = yes (30 feet)
13	Neighborhood	1 = rural 2 = suburban 3 = town or city
14	Dataset number	
15	Unit type	-2 = Original EMDEX -1 = EMDEX II v1.2 0 = EMDEX II v2.x 7 = High-field EMDEX II 20 = Low-field low-resolution LITE 21 = Low-field high-resolution LITE 22 = High-field low-resolution LITE 23 = High-field high-resolution LITE
16	Sampling interval	
17	Composite number	0 = excluded data 1 = included data
18	Consolidated location	0 = unknown 1 = home 2 = Workplace 3 = School 4 = Travel 5 = Other
19	Partition number	chronological within session

Field number	Description	Codes/Units
20	Location	1 = home 2 = home kitchen 3 = home other 4 = other: auto parts store 5 = other: bank 6 = other: chinatown 7 = other: class 8 = other: coffee shop 9 = other: cottage 10 = other: dmv 11 = other: friend's home 12 = other: friend's kitchen 13 = other: grocery store 14 = other: gym 15 = other: investigator's house 16 = other: library 17 = other: neighbor's driveway 18 = other: other person's dining room nook 19 = other: outdoors 20 = other: parents' kitchen 21 = other: park 22 = other: pet food store 23 = other: pick up breakfast 24 = other: restaurant 25 = other: school 26 = other: shopping center 27 = other: store 28 = other: store, bank, post office 29 = other: warehouse 30 = travel 31 = workplace

Field number	Description	Codes/Units
21	Activity description	1 = accounting work 2 = arrive at work 3 = arrived home, cleaned house (meter not worn) 4 = at bank 5 = at home 6 = at home in kitchen 7 = at library 8 = at pet food store 9 = at school 10 = at video store 11 = at work 12 = ate at dim sum restaurant 13 = ate at restaurant 14 = ate breakfast at restaurant 15 = ate dinner 16 = ate lunch, walked dog around block 17 = attended spanish class 18 = began protocol 19 = beginning protocol 20 = brush teeth, go to bed 21 = chatting with investigator 22 = clean up and get daughter dressed 23 = cleaned 24 = cleaned boat 25 = cleaned house 26 = completed protocol 27 = cooked 28 = cooked dinner 29 = cooking 30 = dialed modem on computer 31 = dinner at restaurant 32 = dinner in kitchen 33 = discuss project with investigator 34 = dmv to get license 35 = do dishes, make breakfast 36 = downstairs chores 37 = drive to dmv 38 = drive to work 39 = drove home 40 = drove home from work 41 = drove to alameda 42 = drove to auto parts store 43 = drove to blake/mlk 44 = drove to city 45 = drove to coffee shop 46 = drove to conta madera to pick up son 47 = drove to east bay 48 = drove to emeryville 49 = drove to exercise 50 = drove to friend's home 51 = drove to friend's house

Field number	Description	Codes/Units
		54 = drove to liquor store 55 = drove to lunch 56 = drove to marina 57 = drove to market 58 = drove to montclair 59 = drove to parents' house 60 = drove to parents' house to drop off gift 61 = drove to park 62 = drove to restaurant 63 = drove to san francisco 64 = drove to santa rosa 65 = drove to school 66 = drove to video store 67 = drove to work 68 = drove-mail and eat 69 = eat lunch 70 = eat then nap 71 = eating 72 = exercise 73 = fed animals and made coffee 74 = fixed dinner 75 = fixing breakfast 76 = getting ready for bed 77 = getting ready for work 78 = getting ready to go out 79 = getting ready to leave 80 = go to storage area in alameda 81 = got dressed 82 = got dressed and ready for work 83 = got kids ready for school, got ready for work 84 = got ready for bed 85 = got ready for work 86 = got up, fixed breakfast 87 = got up, got ready for yoga and work 88 = got up; personal care; talk to girls; breakfast 89 = had breakfast 90 = had coffee, read paper 91 = had dinner 92 = had dinner and worked on computer at home 93 = had lunch 94 = having dinner 95 = heated up lunch in microwave 96 = help in packing 97 = home in bedroom 98 = home unpacking 99 = house work; play with baby 100 = household chores 101 = hung out and read in bedroom 102 = hung out at home 103 = hung out downstairs 104 = hung out in bed (meter on)

Field number	Description	Codes/Units
		107 = in car and shopping 108 = in den 109 = in home office 110 = in kitchen 111 = in market 112 = in park 113 = inside restaurant to order takeout 114 = learning protocol 115 = left for work 116 = lunch at restaurant 117 = lunch with family 118 = made breakfast 119 = made copies 120 = made dinner 121 = made lunch in kitchen 122 = make lunches 123 = making dinner 124 = meeting in office 125 = napped without meter; left meter in kitchen 126 = ordered take-out dinner at restaurant 127 = outside of home 128 = outside on patio 129 = paper work 130 = personal care 131 = pick up daughter at school (near large electrical substation) 132 = pick up kids at park 133 = picked strawberries 134 = played with son and put him to bed 135 = prepare for sleep 136 = prepared breakfast 137 = preparing dinner 138 = punched in 139 = punched out 140 = put meter back on 141 = put meter back on, got ready for bed 142 = putting baby to sleep 143 = read and talk 144 = read and tuck in daughter 145 = read in kitchen 146 = read, watched football, talked 147 = reading in bedroom 148 = relax at home 149 = relaxed at home 150 = relaxed in bedroom 151 = relaxing at home 152 = rest in bedroom, then vacuum 153 = return home by car 154 = returned to work 155 = rode bike from car to work 156 = rode bike home

Field number	Description	Codes/Units
		159 = rode bike to work 160 = rode elevator down 161 = rode elevator to 3rd floor 162 = rode motorcycle home 163 = rode motorcycle to work (forgot meter) 164 = sat down to eat 165 = sewing 166 = shopping 167 = shopping at beverage store 168 = shopping at bookstore 169 = shopping at drug store 170 = shopping at grocery store 171 = shopping at liquor store 172 = shopping, bank, post office 173 = sitting in den watching tv 174 = sleep 175 = started protocol 176 = started work 177 = started work, turned on cd player and flourescent lights 178 = starting protocol 179 = stop for breakfast food 180 = stopped at grocery store 181 = stopped for coffee 182 = straighten up house 183 = study at home 184 = studying protocol 185 = take care of baby 186 = took a nap 187 = took kids to park by car and returned home 188 = took nap 189 = took nap (meter on) 190 = took shower 191 = took shower (meter off) 192 = took son to play swings 193 = travel by car 194 = travel by car as part of work 195 = travel by car to pick up kids and return home 196 = travel home 197 = travel to bank 198 = travel to drug store 199 = turned computer off and back on 200 = turned off computer 201 = turned on computer 202 = turned on stereo 203 = used computer 204 = using computer 205 = visit neighbor 206 = visiting parents 207 = visiting with friend 208 = walk dog at park

Field number	Description	Codes/Units
		213 = walked home 214 = walked in park 215 = walked to pick up lunch 216 = walked to restaurant 217 = watch video at home 218 = watched baseball game 219 = watched tv 220 = watched tv and snoozed in den 221 = watched tv in bedroom 222 = watched tv upstairs 223 = watched video at home 224 = weeded garden, relaxed at home 225 = went for a walk 226 = went outside in garden 227 = went to bed 228 = went to bedroom to watch tv 229 = went to make dinner in kitchen 230 = went to public storage warehouse 231 = went to restaurant 232 = went to sleep (meter left on clock radio) 233 = went to sleep (meter off) 234 = went to the garage to make fishing rods for kids 235 = went to the liquor store 236 = work in office on computer 237 = work outside on car 238 = worked in office 239 = worked on computer 240 = worked on computer in study 241 = working 242 = working (without meter) 243 = working in home office 244 = working on computer 245 = working on sunday school stuff 246 = yoga (meter not worn)
22	Starting date (inclusive)	ANSI X3.30-1985
23	Starting time (inclusive)	ANSI X3.43-1986
24	Ending date (exclusive)	ANSI X3.30-1985
25	Ending time (exclusive)	ANSI X3.43-1986
26	Partitions in record	
27	Measurements in record	
28	Minimum	mG
29	1st percentile	mG
30	2nd percentile	mG
31	5th percentile	mG
32	10th percentile	mG

Field number	Description	Codes/Units
33	15th percentile	mG
34	20th percentile	mG
35	25th percentile	mG
36	30th percentile	mG
37	35th percentile	mG
38	40th percentile	mG
39	45th percentile	mG
40	50th percentile	mG
41	55th percentile	mG
42	60th percentile	mG
43	65th percentile	mG
44	70th percentile	mG
45	75th percentile	mG
46	80th percentile	mG
47	85th percentile	mG
48	90th percentile	mG
49	95th percentile	mG
50	98th percentile	mG
51	99th percentile	mG
52	Maximum	mG
53	Mean	mG
54	Standard deviation	mG
55	Geometric mean	mG
56	Geometric standard deviation	mG
57	Measurements exceeding 0.1 mG	
58	Measurements exceeding 0.2 mG	
59	Measurements exceeding 0.5 mG	
60	Measurements exceeding 1.0 mG	
61	Measurements exceeding 2.0 mG	
62	Measurements exceeding 4.0 mG	
63	Measurements exceeding 5.0 mG	
64	Measurements exceeding 8.0 mG	
65	Measurements exceeding 10 mG	
66	Measurements exceeding 16 mG	
67	Measurements exceeding 20 mG	
68	Measurements exceeding 32 mG	
69	Measurements exceeding 50 mG	

Field number	Description	Codes/Units
70	Measurements exceeding 64 mG	
71	Measurements exceeding 100 mG	
72	Measurements exceeding 200 mG	
73	Measurements exceeding 500 mG	
74	Measurements exceeding 1,000 mG	
75	Measurements exceeding 2,000 mG	
76	Measurements exceeding 5,000 mG	
77	Measurements exceeding 10,000 mG	
78	Sum of measurements	
79	Sum of squares of measurement	
80	Sum of natural logarithm	
81	Sum of squares of natural logarithm	
82	Periods exceeding 0.1 mG	
83	Longest period exceeding 0.1 mG	
84	Periods exceeding 0.2 mG	
85	Longest period exceeding 0.2 mG	
86	Periods exceeding 0.5 mG	
87	Longest period exceeding 0.5 mG	
88	Periods exceeding 1.0 mG	
89	Longest period exceeding 1.0 mG	
90	Periods exceeding 2.0 mG	
91	Longest period exceeding 2.0 mG	
92	Periods exceeding 4.0 mG	
93	Longest period exceeding 4.0 mG	
94	Periods exceeding 5.0 mG	
95	Longest period exceeding 5.0 mG	
96	Periods exceeding 8.0 mG	
97	Longest period exceeding 8.0 mG	
98	Periods exceeding 10 mG	
99	Longest period exceeding 10 mG	
100	Periods exceeding 16 mG	
101	Longest period exceeding 16 mG	
102	Periods exceeding 20 mG	

Field number	Description	Codes/Units
103	Longest period exceeding 20 mG	
104	Periods exceeding 32 mG	
105	Longest period exceeding 32 mG	
106	Periods exceeding 50 mG	
107	Longest period exceeding 50 mG	
108	Periods exceeding 64 mG	
109	Longest period exceeding 64 mG	
110	Periods exceeding 100 mG	
111	Longest period exceeding 100 mG	
112	Periods exceeding 200 mG	
113	Longest period exceeding 200 mG	
114	Periods exceeding 500 mG	
115	Longest period exceeding 500 mG	
116	Periods exceeding 1,000 mG	
117	Longest period exceeding 1,000 mG	
118	Periods exceeding 2,000 mG	
119	Longest period exceeding 2,000 mG	
120	Periods exceeding 5,000 mG	
121	Longest period exceeding 5,000 mG	
122	Periods exceeding 10,000 mG	
123	Longest period exceeding 10,000 mG	
124	Number of adjacent measurement pairs	
125	Mean absolute first difference	mG
126	Root mean squared first difference	mG
127	Sudden field changes greater than 2.5 mG	
128	Sudden field changes greater than 5.0 mG	
129	Sudden field changes greater than 10.0 mG	

APPENDIX E

MODEL RESULTS

Table E-1 Estimated Total TWA Exposure by Subject by TWA Source Level E-1
Table E-2 Estimated Home TWA Exposure by Subject by TWA Source Level E-5
Table E-3 Estimated Work TWA Exposure E-9
Table E-4 Estimated School TWA Exposure E-11
Table E-5 Estimated Travel TWA Exposure E-13
Table E-6 Estimated Other TWA Exposure E-15
Table E-7 Estimated Peak Exposure by Peak Source Level E-17
Table E-8 Estimated Harmonic Fraction Above Threshold by TWA Source Level E-19

Table E-1
Estimated Total TWA Exposure by Subject by TWA Source Level

Subject	**1**			**2**			**3**			**4**		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.30	0.80	0.78	1.55	1.46	1.46	1.92	1.66	1.66	2.57	2.26	2.26
Std Deviation	0.30	0.28	0.28	0.83	0.83	0.84	1.18	1.18	1.20	1.71	1.84	1.87
Minimum	0.59	0.26	0.24	0.52	0.42	0.42	0.58	0.38	0.36	0.69	0.33	0.31
5th Percentile	0.88	0.42	0.39	0.71	0.62	0.62	0.82	0.56	0.55	1.14	0.76	0.75
25th Percentile	1.08	0.59	0.57	0.93	0.84	0.84	1.17	0.91	0.90	1.59	1.18	1.17
50th Percentile	1.26	0.76	0.74	1.26	1.17	1.17	1.57	1.32	1.31	2.10	1.76	1.76
75th Percentile	1.46	0.94	0.92	1.99	1.89	1.89	2.41	2.17	2.17	2.96	2.65	2.65
95th Percentile	1.86	1.35	1.33	3.11	3.03	3.03	3.80	3.53	3.53	5.64	5.55	5.59
Maximum	2.40	1.84	1.83	9.50	9.40	9.40	13.81	13.56	13.77	24.76	26.31	26.65
Measured TWA	0.38			0.65			1.48			1.06		

Subject	**5**			**6**			**7**			**8**		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	0.63	0.54	0.54	2.01	1.30	1.30	1.44	1.23	1.23	2.03	1.32	1.31
Std Deviation	0.28	0.28	0.28	0.47	0.74	0.74	0.54	0.63	0.63	0.64	0.69	0.70
Minimum	0.17	0.09	0.09	0.94	0.36	0.38	0.58	0.32	0.32	1.00	0.45	0.43
5th Percentile	0.25	0.16	0.16	1.39	0.52	0.52	0.83	0.54	0.54	1.32	0.62	0.59
25th Percentile	0.41	0.32	0.32	1.68	0.76	0.76	1.04	0.76	0.76	1.57	0.81	0.79
50th Percentile	0.60	0.51	0.51	1.91	1.02	1.02	1.27	1.01	1.01	1.81	1.05	1.03
75th Percentile	0.79	0.71	0.71	2.26	1.65	1.65	1.73	1.53	1.53	2.33	1.62	1.62
95th Percentile	1.19	1.11	1.11	2.97	2.90	2.90	2.59	2.57	2.57	3.42	2.83	2.83
Maximum	1.60	1.53	1.53	3.69	3.68	3.68	3.15	3.15	3.15	3.87	3.28	3.28
Measured TWA	0.11			0.26			0.94			0.69		

Subject	9			10			11			12		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.92	1.50	1.50	1.75	1.20	1.20	2.13	2.12	2.12	1.98	1.98	1.98
Std Deviation	0.64	0.73	0.73	0.59	0.81	0.81	1.65	1.65	1.65	1.50	1.50	1.50
Minimum	0.83	0.43	0.41	0.75	0.26	0.25	0.38	0.37	0.37	0.37	0.37	0.37
5% Perc	1.11	0.63	0.63	1.10	0.39	0.39	0.60	0.58	0.58	0.61	0.61	0.61
25th Percentile	1.43	0.94	0.93	1.32	0.59	0.59	0.99	0.97	0.97	0.97	0.97	0.97
50th Percentile	1.78	1.31	1.31	1.55	0.85	0.85	1.46	1.44	1.44	1.39	1.39	1.39
75th Percentile	2.32	1.95	1.95	2.05	1.60	1.60	2.67	2.66	2.67	2.53	2.53	2.53
95th Percentile	3.14	2.89	2.89	3.03	2.96	2.96	5.70	5.69	5.68	5.32	5.32	5.31
Maximum	4.31	4.19	4.21	3.41	3.40	3.40	9.80	9.81	9.81	10.29	10.29	10.29
Measured TWA	1.30			0.61			0.80			0.74		

Subject	13			14			15			16		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.57	1.57	1.58	1.24	1.20	1.19	1.74	1.74	1.74	2.32	1.42	1.38
Std Deviation	1.10	1.10	1.13	0.54	0.54	0.54	1.40	1.40	1.40	0.83	0.81	0.81
Minimum	0.28	0.28	0.27	0.49	0.45	0.44	0.30	0.30	0.30	1.16	0.44	0.40
5th Percentile	0.55	0.55	0.55	0.65	0.61	0.60	0.54	0.54	0.54	1.49	0.65	0.61
25th Percentile	0.84	0.84	0.85	0.84	0.80	0.80	0.92	0.92	0.92	1.82	0.92	0.87
50th Percentile	1.29	1.29	1.30	1.06	1.01	1.01	1.40	1.40	1.40	2.15	1.22	1.18
75th Percentile	2.03	2.03	2.03	1.48	1.44	1.44	2.09	2.09	2.09	2.67	1.74	1.70
95th Percentile	3.34	3.34	3.40	2.42	2.38	2.37	4.05	4.05	4.05	3.61	2.68	2.66
Maximum	14.22	14.22	14.75	2.95	2.91	2.91	20.96	20.96	20.96	14.62	13.59	13.55
Measured TWA	0.96			0.62			1.13			0.68		

Subject	17			18			19			20		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.30	1.30	1.30	1.55	1.37	1.37	0.88	0.87	0.87	1.73	1.73	1.73
Std Deviation	0.59	0.59	0.59	0.66	0.73	0.73	0.53	0.53	0.53	0.79	0.79	0.79
Minimum	0.44	0.44	0.44	0.60	0.35	0.35	0.24	0.23	0.23	0.55	0.55	0.55
5th Percentile	0.64	0.63	0.63	0.77	0.52	0.52	0.37	0.37	0.37	0.81	0.81	0.81
25th Percentile	0.85	0.85	0.85	1.05	0.83	0.83	0.49	0.49	0.49	1.14	1.15	1.15
50th Percentile	1.12	1.12	1.12	1.37	1.20	1.21	0.64	0.63	0.63	1.53	1.53	1.53
75th Percentile	1.63	1.62	1.62	1.92	1.77	1.78	1.10	1.09	1.09	2.18	2.19	2.19
95th Percentile	2.50	2.50	2.50	2.79	2.68	2.67	2.06	2.06	2.06	3.18	3.18	3.18
Maximum	4.49	4.49	4.49	4.79	6.15	6.26	2.32	2.32	2.32	8.14	8.16	8.16
Measured TWA	0.62			0.85			0.94			2.00		

Table E-2
Estimated Home TWA Exposure by Subject by TWA Source Level

Subject	1			2			3			4		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.52	0.78	0.76	1.60	1.45	1.45	1.93	1.43	1.42	2.45	1.28	1.24
Std Deviation	0.37	0.33	0.33	0.93	0.94	0.94	0.94	0.95	0.96	0.71	0.68	0.70
Minimum	0.71	0.26	0.24	0.56	0.42	0.41	0.69	0.34	0.32	0.95	0.38	0.31
5th Percentile	1.01	0.37	0.34	0.72	0.57	0.57	1.00	0.51	0.50	1.56	0.54	0.49
25th Percentile	1.24	0.53	0.50	0.92	0.76	0.76	1.24	0.72	0.70	1.94	0.74	0.70
50th Percentile	1.47	0.74	0.71	1.18	1.02	1.01	1.56	1.02	1.00	2.29	1.06	1.02
75th Percentile	1.73	0.93	0.91	1.97	1.83	1.83	2.33	1.81	1.80	2.84	1.64	1.62
95th Percentile	2.23	1.40	1.39	3.70	3.56	3.56	4.00	3.56	3.56	3.89	2.73	2.73
Maximum	2.77	1.91	1.90	4.12	3.99	3.99	4.50	3.96	3.96	4.89	3.64	3.64
Measured TWA	0.31			0.52			2.07			1.01		

Subject	5			6			7			8		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	0.59	0.45	0.45	2.23	1.30	1.30	1.78	1.37	1.37	2.62	1.43	1.41
Std Deviation	0.37	0.37	0.37	0.52	0.75	0.75	0.77	0.90	0.90	0.89	0.95	0.96
Minimum	0.07	0.00	0.00	0.93	0.31	0.36	0.66	0.33	0.33	1.09	0.35	0.31
5th Percentile	0.14	0.01	0.00	1.50	0.53	0.53	0.99	0.49	0.49	1.59	0.52	0.49
25th Percentile	0.27	0.12	0.12	1.85	0.73	0.73	1.22	0.70	0.70	1.96	0.73	0.70
50th Percentile	0.54	0.40	0.40	2.16	1.02	1.02	1.49	0.99	0.99	2.33	1.01	0.99
75th Percentile	0.79	0.64	0.64	2.52	1.64	1.64	2.11	1.73	1.73	3.03	1.80	1.79
95th Percentile	1.27	1.15	1.15	3.23	2.98	2.98	3.48	3.39	3.39	4.54	3.55	3.55
Maximum	1.82	1.70	1.70	3.94	3.73	3.73	3.92	3.88	3.88	5.31	3.95	3.95
Measured TWA	0.03			0.26			0.51			0.38		

Subject	9			10			11			12		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	2.13	1.29	1.28	2.17	1.29	1.29	2.47	2.44	2.44	2.43	2.43	2.43
Std Deviation	0.85	1.01	1.01	0.75	1.01	1.01	2.87	2.89	2.89	2.89	2.89	2.89
Minimum	0.73	0.22	0.21	0.79	0.21	0.21	0.30	0.26	0.26	0.25	0.25	0.25
5th Percentile	1.17	0.30	0.29	1.28	0.29	0.29	0.46	0.42	0.42	0.41	0.41	0.41
25th Percentile	1.50	0.52	0.51	1.62	0.52	0.52	0.68	0.64	0.64	0.63	0.63	0.63
50th Percentile	1.84	0.82	0.81	1.95	0.82	0.82	1.30	1.25	1.25	1.25	1.25	1.25
75th Percentile	2.52	1.71	1.71	2.53	1.72	1.72	2.01	1.98	1.98	1.97	1.97	1.97
95th Percentile	3.95	3.50	3.50	3.75	3.51	3.51	9.56	9.56	9.56	9.55	9.55	9.55
Maximum	4.59	3.91	3.91	4.41	3.92	3.92	11.98	11.98	11.98	11.97	11.97	11.97
Measured TWA	0.48			0.59			0.74			0.74		

Subject	13			14			15			16		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.37	1.37	1.37	1.48	1.38	1.37	1.36	1.36	1.36	3.20	1.37	1.30
Std Deviation	0.98	0.98	0.98	0.97	0.97	0.97	0.97	0.97	0.97	0.83	0.74	0.75
Minimum	0.31	0.31	0.31	0.44	0.34	0.34	0.32	0.33	0.33	1.33	0.48	0.37
5th Percentile	0.43	0.43	0.43	0.56	0.46	0.46	0.44	0.45	0.45	2.11	0.62	0.54
25th Percentile	0.64	0.64	0.64	0.76	0.66	0.66	0.64	0.64	0.64	2.61	0.81	0.74
50th Percentile	0.92	0.92	0.92	1.04	0.94	0.94	0.93	0.93	0.93	3.02	1.09	1.02
75th Percentile	1.77	1.77	1.77	1.85	1.76	1.76	1.74	1.74	1.74	3.65	1.72	1.64
95th Percentile	3.54	3.54	3.54	3.63	3.54	3.53	3.52	3.52	3.52	4.86	3.00	2.96
Maximum	3.97	3.97	3.97	4.06	3.96	3.96	3.95	3.95	3.95	5.81	3.73	3.72
Measured TWA	0.32			0.36			0.77			0.60		

Subject	17			18			19			20		
TWA Source Level	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01	1	0.05	0.01
Estimated TWA												
Mean	1.43	1.42	1.42	1.66	1.36	1.36	0.87	0.87	0.87	1.45	1.45	1.45
Std Deviation	0.95	0.95	0.95	0.89	0.97	0.97	0.58	0.58	0.58	0.95	0.95	0.95
Minimum	0.39	0.39	0.39	0.58	0.32	0.33	0.24	0.23	0.23	0.40	0.40	0.40
5th Percentile	0.54	0.54	0.54	0.79	0.44	0.45	0.33	0.33	0.33	0.56	0.56	0.56
25th Percentile	0.73	0.72	0.72	1.00	0.64	0.64	0.45	0.44	0.44	0.75	0.75	0.75
50th Percentile	0.99	0.98	0.98	1.28	0.93	0.93	0.61	0.60	0.60	1.01	1.01	1.01
75th Percentile	1.80	1.79	1.79	2.03	1.74	1.74	1.10	1.10	1.10	1.82	1.82	1.82
95th Percentile	3.55	3.55	3.55	3.63	3.52	3.52	2.18	2.18	2.18	3.56	3.56	3.56
Maximum	3.97	3.97	3.97	4.08	3.95	3.95	2.44	2.44	2.44	3.99	3.99	3.99
Measured TWA	0.37			0.73			0.89			1.66		

Table E-3
Estimated Work TWA Exposure

Subject	3	4	5	9	11	12	13
TWA Source Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Estimated TWA							
Mean	2.15	2.67	9.06	2.26	2.09	2.10	5.00
Std Deviation	3.20	2.81	0.58	1.55	2.41	2.33	3.03
Minimum	0.04	0.12	8.07	0.30	0.04	0.05	2.94
5th Percentile	0.21	0.43	8.36	0.74	0.31	0.31	3.09
25th Percentile	0.59	1.01	8.65	1.29	0.74	0.75	3.45
50th Percentile	1.21	1.82	8.94	1.91	1.38	1.39	4.05
75th Percentile	2.49	3.29	9.33	2.81	2.54	2.57	5.31
95th Percentile	7.06	7.73	10.15	4.93	6.20	6.26	10.03
Maximum	54.04	31.80	12.96	25.60	35.55	27.33	39.53
Measured TWA	0.43	0.87	0.39	3.47	0.40	0.12	1.45

Subject	14	15	16	17	18	20
TWA Source Level	N/A	N/A	N/A	N/A	N/A	N/A
Estimated TWA						
Mean	1.05	2.10	2.36	1.33	2.86	2.31
Std Deviation	0.38	2.33	3.99	0.84	0.58	1.43
Minimum	0.31	0.06	0.12	0.19	2.19	0.35
5th Percentile	0.55	0.31	0.28	0.45	2.31	0.78
25th Percentile	0.77	0.75	0.66	0.77	2.48	1.35
50th Percentile	0.98	1.39	1.30	1.12	2.70	1.97
75th Percentile	1.24	2.57	2.64	1.66	3.04	2.88
95th Percentile	1.77	6.28	7.63	2.94	3.96	5.01
Maximum	3.55	28.06	85.01	7.88	7.52	13.98
Measured TWA	0.64	1.21	0.80	0.57	0.95	2.59

Table E-4
Estimated School TWA Exposure

Subject	5
TWA Source Level	N/A
Estimated TWA	
Mean	0.85
Std Deviation	0.68
Minimum	0.20
5th Percentile	0.20
25th Percentile	0.30
50th Percentile	0.70
75th Percentile	0.90
95th Percentile	2.31
Maximum	3.28
Measured TWA	0.07

Table E-5
Estimated Travel TWA Exposure

Subject	1	2	3	4	5	7	8	9	10	11	12	13
TWA Source Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Estimated TWA												
Mean	0.88	0.88	0.87	0.87	0.38	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Std Deviation	0.74	0.74	0.74	0.74	0.48	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Minimum	0.08	0.07	0.08	0.08	0.02	0.08	0.08	0.08	0.08	0.08	0.08	0.08
5th Percentile	0.11	0.11	0.10	0.11	0.05	0.10	0.10	0.10	0.10	0.10	0.10	0.10
25th Percentile	0.20	0.20	0.20	0.20	0.10	0.20	0.20	0.20	0.20	0.20	0.20	0.20
50th Percentile	0.60	0.61	0.60	0.60	0.20	0.60	0.60	0.60	0.60	0.59	0.60	0.60
75th Percentile	1.40	1.39	1.40	1.40	0.40	1.40	1.40	1.40	1.40	1.41	1.40	1.40
95th Percentile	2.20	2.20	2.20	2.20	1.41	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Maximum	3.00	3.00	3.00	3.00	2.60	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Measured TWA	1.21	1.25	1.30	2.88	0.36	1.76	0.97	0.94	0.90	1.46	1.16	1.02

Subject	14	15	16	17	18	19	20
TWA Source Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Estimated TWA							
Mean	0.88	0.87	0.87	0.87	0.87	0.88	0.87
Std Deviation	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Minimum	0.08	0.08	0.08	0.08	0.09	0.09	0.08
5th Percentile	0.10	0.10	0.10	0.10	0.10	0.10	0.09
25th Percentile	0.20	0.20	0.20	0.20	0.19	0.20	0.20
50th Percentile	0.60	0.60	0.60	0.60	0.60	0.60	0.59
75th Percentile	1.40	1.40	1.40	1.40	1.40	1.40	1.41
95th Percentile	2.20	2.20	2.20	2.20	2.19	2.20	2.20
Maximum	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Measured TWA	1.42	1.25	0.57	1.21	0.97	1.48	1.72

Table E-6
Estimated Other TWA Exposure

Subject	1	2	4	5	7	8	9	10	11	12	13	14
TWA Source Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Estimated TWA												
Mean	0.81	0.82945	0.7736	0.37771	0.84045	1.10094	0.93214	0.79719	0.84496	0.84496	0.82945	0.84496
Std Deviation	0.66	0.71	0.49	0.48	0.52	0.36	0.46	0.48	0.68	0.68	0.71	0.68
Minimum	0.19	0.08	0.17	0.02	0.17	0.44	0.31	0.19	0.20	0.20	0.08	0.20
5th Percentile	0.19	0.10	0.24	0.05	0.23	0.62	0.42	0.28	0.20	0.20	0.10	0.20
25th Percentile	0.29	0.20	0.42	0.10	0.47	0.84	0.60	0.45	0.30	0.30	0.20	0.30
50th Percentile	0.67	0.60	0.64	0.20	0.70	1.04	0.81	0.67	0.70	0.70	0.60	0.70
75th Percentile	0.86	1.20	0.92	0.40	1.06	1.32	1.07	0.92	0.90	0.90	1.20	0.90
95th Percentile	2.21	2.20	1.85	1.42	1.96	1.75	1.91	1.85	2.31	2.31	2.20	2.31
Maximum	3.16	2.99	2.74	2.60	2.87	2.53	2.75	2.64	3.30	3.30	2.99	3.30
Measured TWA	0.43	0.95	0.50	0.52	2.19	2.12	0.82	0.54	2.65	2.56	0.18	2.43

Subject	16	17	18	19
TWA Source Level	N/A	N/A	N/A	N/A
Estimated TWA				
Mean	0.82	0.81	1.67	0.84
Std Deviation	0.41	0.56	0.29	0.52
Minimum	0.20	0.12	0.00	0.17
5th Percentile	0.32	0.20	1.21	0.23
25th Percentile	0.53	0.35	1.54	0.47
50th Percentile	0.71	0.64	1.73	0.71
75th Percentile	1.00	1.13	1.87	1.07
95th Percentile	1.70	1.90	1.98	1.93
Maximum	2.47	2.56	2.00	2.85
Measured TWA	1.27	6.31	2.25	1.38

Table E-7
Estimated Peak Exposure by Peak Source Level

Subject	1			2			3			4		
Peak Source Level	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01
Estimated Peak												
Mean	2400.00	239.99	120.00	2400.00	250.96	139.61	2400.00	250.96	139.61	4300.00	436.33	226.82
5th Percentile	2400.00	160.88	80.52	2400.00	163.70	84.52	2400.00	163.70	84.52	4300.00	291.33	146.12
50th Percentile	2400.00	239.92	119.96	2400.00	242.58	122.38	2400.00	242.58	122.38	4300.00	431.06	217.14
95th Percentile	2400.00	318.57	159.45	2400.00	331.81	209.54	2400.00	331.81	209.54	4300.00	577.86	302.54
Maximum	2400.00	403.97	195.16	2400.00	1609.01	1609.01	2400.00	1609.01	1609.01	4300.00	1609.01	1609.01
Measured Peak	59.70			25.10			34.50			16.10		

Subject	5			6			7			8		
Peak Source Level	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01
Estimated Peak												
Mean	9200.00	922.19	466.21	2400.00	239.99	120.00	2400.00	239.99	120.00	3000.00	299.99	150.00
5th Percentile	9200.00	618.97	311.68	2400.00	160.88	80.52	2400.00	160.88	80.52	3000.00	201.10	100.65
50th Percentile	9200.00	921.46	461.10	2400.00	239.92	119.96	2400.00	239.92	119.96	3000.00	299.90	149.95
95th Percentile	9200.00	1226.60	618.17	2400.00	318.57	159.45	2400.00	318.57	159.45	3000.00	398.21	199.32
Maximum	9200.00	1609.01	1609.01	2400.00	403.97	195.16	2400.00	403.97	195.16	3000.00	504.96	243.96
Measured Peak	8.43			20.70			53.30			76.70		

Subject	9			10			11			12		
Peak Source Level	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01
Estimated Peak												
Mean	3000.00	308.99	165.97	2400.00	239.99	120.00	4700.00	475.84	245.95	1400.35	157.43	102.69
5th Percentile	3000.00	203.68	103.17	2400.00	160.88	80.52	4700.00	318.43	159.71	1400.00	98.43	52.71
50th Percentile	3000.00	303.08	152.48	2400.00	239.92	119.96	4700.00	471.16	237.10	1400.00	142.80	80.31
95th Percentile	3000.00	403.56	227.67	2400.00	318.57	159.45	4700.00	630.86	327.03	1400.00	218.06	209.54
Maximum	3000.00	1609.01	1609.01	2400.00	403.97	195.16	4700.00	1609.01	1609.01	1609.01	1609.01	1609.01
Measured Peak	19.90			56.50			24.10			10.21		

Subject	13			14			15			16		
Peak Source Level	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01
Estimated Peak												
Mean	1400.35	157.43	102.62	1400.35	157.43	102.69	134.35	85.16	85.12	1400.35	157.43	102.70
5th Percentile	1400.00	98.43	51.94	1400.00	98.43	52.71	115.00	21.20	21.20	1400.00	98.43	52.71
50th Percentile	1400.00	142.80	80.31	1400.00	142.80	80.31	115.00	54.12	54.12	1400.00	142.80	80.31
95th Percentile	1400.00	218.06	209.54	1400.00	218.06	209.54	210.08	210.08	210.08	1400.00	218.06	209.54
Maximum	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01
Measured Peak	8.64			26.30			31.10			139.70		

Subject	17			18			19			20		
Peak Source Level	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01	1	0.1	0.01
Estimated Peak												
Mean	1400.35	157.43	102.63	1400.35	157.43	102.62	2400.00	239.99	120.00	2400.00	250.96	139.61
5th Percentile	1400.00	98.43	51.94	1400.00	98.43	51.94	2400.00	160.88	80.52	2400.00	163.70	84.52
50th Percentile	1400.00	142.80	80.31	1400.00	142.80	80.31	2400.00	239.92	119.96	2400.00	242.58	122.38
95th Percentile	1400.00	218.06	209.54	1400.00	218.06	209.54	2400.00	318.57	159.45	2400.00	331.81	209.54
Maximum	1609.01	1609.01	1609.01	1609.01	1609.01	1609.01	2400.00	403.97	195.16	2400.00	1609.01	1609.01
Measured Peak	14.10			12.47			44.10			120.10		

Table E-8
Estimated Harmonic Fraction Above Threshold by TWA Source Level

Subject	**1**		**2**		**3**		**4**	
TWA Source Level	1	0.05	1	0.05	1	0.05	1	0.05
Estimated Median								
Fraction > 0.1 mG	0.82	0.88	0.84	0.77	0.78	0.64	0.41	0.36
Fraction > 0.2 mG	0.22	0.06	0.46	0.24	0.31	0.12	0.24	0.22
Fraction > 0.5 mG	0.08	0.00	0.25	0.00	0.19	0.00	0.04	0.00
Estimated Mean								
Fraction > 0.1 mG	0.65	0.62	0.75	0.64	0.68	0.52	0.38	0.34
Fraction > 0.2 mG	0.38	0.26	0.56	0.41	0.48	0.33	0.24	0.22
Fraction > 0.5 mG	0.10	0.02	0.23	0.12	0.20	0.11	0.10	0.06
Measured Mean	0.10		0.15		0.46		0.26	
Fraction > 0.1 mG	0.70		0.79		0.86		0.87	
Fraction > 0.2 mG	0.09		0.14		0.26		0.51	
Fraction > 0.5 mG	0.01		0.02		0.22		0.13	

Subject	**5**		**6**		**7**		**8**	
TWA Source Level	1	0.05	1	0.05	1	0.05	1	0.05
Estimated Median								
Fraction > 0.1 mG	0.09	0.07	0.77	0.77	0.78	0.78	0.85	0.85
Fraction > 0.2 mG	0.02	0.00	0.31	0.31	0.34	0.33	0.27	0.29
Fraction > 0.5 mG	0.02	0.00	0.00	0.00	0.03	0.00	0.04	0.03
Estimated Mean								
Fraction > 0.1 mG	0.31	0.32	0.73	0.74	0.71	0.70	0.73	0.73
Fraction > 0.2 mG	0.13	0.11	0.44	0.46	0.43	0.44	0.44	0.47
Fraction > 0.5 mG	0.03	0.01	0.14	0.13	0.14	0.13	0.15	0.14
Measured Mean	0.06		0.03		0.26		0.12	
Fraction > 0.1 mG	0.16		0.16		0.80		0.35	
Fraction > 0.2 mG	0.09		0.03		0.25		0.14	
Fraction > 0.5 mG	0.04		0.00		0.15		0.04	

Subject	9		10		11		12	
TWA Source Level	1	0.05	1	0.05	1	0.05	1	0.05
Estimated Median								
Fraction > 0.1 mG	0.65	0.66	0.83	0.88	0.56	0.56	0.51	0.51
Fraction > 0.2 mG	0.11	0.11	0.23	0.17	0.47	0.46	0.42	0.42
Fraction > 0.5 mG	0.02	0.01	0.06	0.00	0.00	0.00	0.00	0.00
Estimated Mean								
Fraction > 0.1 mG	0.49	0.50	0.66	0.66	0.46	0.46	0.46	0.46
Fraction > 0.2 mG	0.31	0.32	0.43	0.42	0.31	0.31	0.30	0.31
Fraction > 0.5 mG	0.11	0.11	0.16	0.13	0.14	0.13	0.12	0.12
Measured Mean	0.29		0.25		0.17		0.13	
Fraction > 0.1 mG	0.88		0.86		0.72		0.67	
Fraction > 0.2 mG	0.73		0.67		0.20		0.22	
Fraction > 0.5 mG	0.08		0.04		0.06		0.01	

Subject	13		14		15		16	
TWA Source Level	1	0.05	1	0.05	1	0.05	1	0.05
Estimated Median								
Fraction > 0.1 mG	0.64	0.64	0.58	0.59	0.36	0.36	0.61	0.61
Fraction > 0.2 mG	0.22	0.21	0.10	0.10	0.17	0.09	0.32	0.37
Fraction > 0.5 mG	0.02	0.00	0.00	0.00	0.08	0.00	0.01	0.00
Estimated Mean								
Fraction > 0.1 mG	0.52	0.53	0.46	0.47	0.34	0.32	0.56	0.56
Fraction > 0.2 mG	0.33	0.32	0.28	0.29	0.24	0.20	0.34	0.35
Fraction > 0.5 mG	0.12	0.10	0.09	0.09	0.09	0.06	0.10	0.09
Measured Mean	0.12		0.12		0.37		0.10	
Fraction > 0.1 mG	0.71		0.49		0.86		0.46	
Fraction > 0.2 mG	0.11		0.16		0.54		0.15	
Fraction > 0.5 mG	0.01		0.02		0.14		0.01	

Subject	17		18		19		20	
TWA Source Level	1	0.05	1	0.05	1	0.05	1	0.05
Estimated Median								
Fraction > 0.1 mG	0.62	0.62	0.63	0.48	0.61	0.61	0.59	0.59
Fraction > 0.2 mG	0.14	0.16	0.13	0.03	0.08	0.09	0.15	0.15
Fraction > 0.5 mG	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Estimated Mean								
Fraction > 0.1 mG	0.53	0.53	0.51	0.38	0.50	0.50	0.51	0.50
Fraction > 0.2 mG	0.31	0.33	0.35	0.22	0.29	0.31	0.31	0.32
Fraction > 0.5 mG	0.10	0.09	0.15	0.07	0:09	0.09	0.10	0.10
Measured Mean	0.16		0.18		0.22		0.25	
Fraction > 0.1 mG	0.51		0.72		0.99		0.74	
Fraction > 0.2 mG	0.08		0.47		0.45		0.44	
Fraction > 0.5 mG	0.02		0.03		0.02		0.03	