



NIOSH HEALTH HAZARD EVALUATION REPORT

**HETA #2002-0441-2920
Yosemite National Park
El Portal, California**

December 2003



DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by John Cardarelli and Mark Methner of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Ellen Blythe and Shawna Watts. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Radiofrequency at Yosemite National Park

NIOSH representatives conducted a health hazard evaluation at Yosemite National Park in Yosemite, California, on October 22, 2002. They looked into concerns about exposures to radio frequency (RF) fields coming from an antenna base station which is located near the center of Tuolumne Meadows camp site.

What NIOSH Did

- Electric and magnetic fields measurements were made at 27 locations throughout the camp site.
- Met with Park Management and employees to discuss measurement techniques and health effects from RF field exposures.

What NIOSH Found

- All of the RF and magnetic field measurements were below the exposure limits applicable to the general population.
- No RF exposure hazards exist from the base-station cellular communication system located in the Tuolumne Meadows Camp Site.

What Yosemite National Park Employees and Managers Can Do

- Learn more about the health effects from RF exposures by visiting the following websites:
 - NIOSH: <http://www.cdc.gov/niosh/emfpg.html>
 - FDA: <http://www.fda.gov/cellphones>
 - FCC: <http://www.fcc.gov/oet/rfsafetv>
 - IEEE: <http://www.ieeeusa.org/forum/tis/index.html>



What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2002-0441-2920



**Health Hazard Evaluation Report 2002-0441-2920
Yosemite National Park
El Portal, California
December 2003**

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Mark Methner**

SUMMARY

On September 9, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Yosemite National Park, El Portal, California. The park Safety Office requested an evaluation of potential radio frequency (RF) exposures from a cell-phone antenna base station. On October 22, 2002, NIOSH investigators conducted a site visit at Ranger Camp Tuolumne Meadows and completed a source characterization of the RF fields emitting from the base station. This evaluation assessed occupational exposure to magnetic fields (60 Hz) and electric fields in the frequency range from 100 kilohertz (kHz) to 5 gigahertz (GHz) among workers during a typical daily work regimen.

All of the measurements taken with the Holaday HI-4433 STE probe (electric field) and EMDEX-II ELF instrument (magnetic field) were below their respective limits-of-detection. The only measurable results were obtained with the Holiday HI-6005 probe (electric field); all of these measurements were below the exposure limits applied to the general public. Further, none of the measurements exceeded 0.1 percent of the applicable limit which indicates that the emissions from this base station pose no threat to employees or the general population who visit or pass through the area or to workers at the Tuolumne Meadows Camp Site.

No RF exposure hazards exist from the base-station cellular communication system located in the Tuolumne Meadows Camp Site. This conclusion is based on the fact that: (1) all the measurements were well below any RF exposure limits for the general population, (2) the antenna height (70 feet above grade) prevents accidental exposures within a few feet of the antenna, and (3) the geographic layout provides sufficient distance between the base-station antennas and housing units.

Keywords: SIC 0851 (Forestry Services), Antenna, Non-Ionizing Radiation, Radiofrequency, RF, cellular communications, magnetic fields, electric fields

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INTRODUCTION

On September 9, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Yosemite National Park, El Portal, California. The park Safety Office requested an evaluation of potential radio frequency (RF) exposures from a cell-phone antenna base station. A ranger station and housing units for emergency medical technicians and employees are near the antenna site. There were no reported health problems. On October 22, 2002, NIOSH investigators conducted a site visit at Ranger Camp Tuolumne Meadows and completed a source characterization of the RF fields emitting from the base station.

BACKGROUND

Park Description

Yosemite National Park embraces a vast tract of scenic wild lands set aside in 1890 to preserve a portion of the Sierra Nevada that stretches along California's eastern flank (Figure 1). It is located 150 miles east of San Francisco and ranges from 2,000 to more than 13,000 feet above sea level offering three major features; alpine wilderness, groves of Giant Sequoias, and Yosemite Valley. The park was designated a World Heritage Site in 1984 and contains thousands of lakes and ponds, 1600 miles of streams, 800 miles of hiking trails, and 350 miles of roads throughout its 750,000-acre, 1,200 square-miles area. Two federally designated wild and scenic rivers, the Merced and Tuolumne, begin within Yosemite's borders and flow west into California's Central Valley. Annual park visitation exceeds 3.5 million, with most visitor use concentrated in the seven square mile area of Yosemite Valley.¹

Tuolumne Meadows Camp

The Tuolumne Meadows Camp is located in the northeast part of the park and situated between Tioga Road and Tuolumne Lodge Road along the Tuolumne River (Figure 2). This camp site consists of about 45 housing units that included

a Ranger Station and a base station for wireless communication.

Antenna and Operating Parameters

The requestor provided descriptive information on the antenna and operating parameters of the communication system.² Three DB586-XC antennas are used for this site, which emit signals in all directions for 800 to 900 megahertz (MHz) applications (Photo 1). The antennas fulfill frequency requirements for conventional, trunked, paging, and cellular communications. Radiators in the DB586-XC are enclosed in a 1.5" (39.1 mm) OD Horizon Blue™ radome made of Mirage extruded fiberglass. There is an additional antenna mounted to the top of the base station, but no information was provided on its operating characteristics. This antenna is likely used for two-way communications; contributions from its emissions were included in the field measurements.



Photo 1. Camp antennas.

METHODS

This evaluation assessed occupational exposure to RF fields in the range from 100 kilohertz (kHz) to 5 gigahertz (GHz) among workers during a typical daily work regimen. Magnetic fields were also measured but these measurements were to assess potential exposures from power lines (60 Hz) at the site, if any. The number and types of measurements performed in the evaluation were not intended to represent an in-depth investigation of exposure to all electric and magnetic fields present at the site, as that would require long-term monitoring. Instead this study was intended to estimate occupational exposure levels on the day of the measurements.

The following instruments were used in this evaluation and were calibrated within the year previous to the study:

- Holaday HI-6005 Electric Field Probe: This instrument, manufactured by Holaday Industries, Eden Prairie, Minnesota, is an isotropic (x,y,z axis sensors) probe capable of measuring electric field intensities in the range of 0.5 to 800 volts/meter. The frequency it is capable of responding to lies in the range of 100 kHz to 5 GHz, with a resolution of 0.01 volts/meter.

- Holaday HI-4433 STE Electric Field Probe: This instrument, also manufactured by Holaday Industries, Eden Prairie, Minnesota, is an isotropic (x,y,z axis sensors) probe capable of measuring electric field intensities in the range of 30 to 3000 volts/meter. The frequency it is capable of responding to lies in the range of 500 kHz to 5 GHz, with a resolution of 0.01 volts/meter.

- EMDEX II: Area magnetic field measurements were made with the EMDEX II exposure system developed by EnerTech Consultants, under project sponsorship of the Electric Power Research Institute, Inc. The EMDEX II is a programmable data-acquisition meter which measures the orthogonal vector components of the magnetic field through its internal sensors. Measurements can be made in the instantaneous read or storage mode. This system was designed to measure, record, and analyze power frequency magnetic fields in units of milligauss (mG) in the frequency range from 40 to 800 Hz. The meter has the capability of displaying magnetic field values in 3 different frequency bandwidths: broadband, which measures from 40 to 800 Hz; harmonic, which measures from 100 to 800 Hz; and the fundamental bandwidth, which measures at 60 Hz.

RF intensity measurements were made throughout the Tuolumne Meadows ranger station and camp area. The instruments provide readings every second and the highest measurement was recorded during a five- to fifteen-second monitoring period. The sampling

locations were determined based on proximity to the cellular phone antenna which is mounted in the approximate center of the camp facility. Individual cottages are located around the base of the antenna. Most of the measurements were made at the front door of each cottage; some were made in the center and bedroom area. All measurements were made at approximately five feet above ground level with the exception of a few measurements made at a position corresponding to the top of the antenna. These measurements were achieved by climbing a hill across Tioga road (no housing units) to an elevation and location that was in alignment and closest to the antennas.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. For chemical agents, the primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),³ (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),⁴ and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).⁵ Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the more protective criterion.

Radio frequency (RF) Evaluation Criteria

Guidelines for limiting RF exposure have been developed by several voluntary organizations and government agencies in the United States and elsewhere (Table 2).^{6,7,8,9} The Federal Communications Commission (FCC) requires that all licensed telecommunications facilities comply with its exposure guidelines.¹⁰ These guidelines were developed to protect workers and the general population from harmful

exposure to RF radiation. For workers, the occupational limits (sometimes referred to as controlled environment) apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. For workers that do not satisfy this description, NIOSH applies the exposure limits as define for the general population (sometimes referred to as the uncontrolled environment). The general population exposure limits apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure. The consensus of the scientific community is that exposure to RF radiation below recommended limits is safe.

Three fundamental concepts that apply to these limits are (1) understanding the difference between *exposure* and *emission* limits, (2) spatial averaging, and (3) time averaging. Each of these concepts is described below.

Exposure vs. Emission limits

Exposure limits, as described above, apply to workers and the general public and are designed to prevent harmful effects from exposure to electromagnetic radiation. Emission limits are the maximum power output authorized by the FCC for companies or individuals who apply for a license to transmit signals (e.g., radio and television stations, amateur radio operators). Often times, the transmitting signals are not emitted at the maximum power output. This is especially true for cell-phone base stations or towers, since the amount of power used is proportional to the number of calls handled. For this reason, it is important to note that the emission limit (maximum power output) may not be directly related to specific exposure measurements in the field. The FCC exposure guidelines apply to exposure limits (not *emission* limits), and they are relevant only to locations that are accessible to workers or members of the public. Access can be restricted or controlled by appropriate means by using

fences, warning signs, etc. For the case of occupational (controlled environment) exposure, procedures can be instituted for working in the vicinity of RF sources that will prevent exposures in excess of the guidelines. An example of such procedures would be restricting the time an individual could be near an RF source, or requiring that work on or near such sources be performed while the transmitter is turned off or while power is appropriately reduced.

Spatial Averaging

The exposure limits specified in Table 1 are based on the concept that the exposures are applied to a **whole-body** averaged specific absorption rate (SAR). The spatially-averaged RF field is accepted as the most accurate estimate to compare to the FCC guidelines. This means that **spot measurements** exceeding the stated exposure limits do not imply non-compliance if the spatial average of RF fields over the body does not exceed the limits. Further discussion of spatial averaging as it relates to field measurements can be found in Section 3 of Bulletin 65 and in the American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) and the National Council on Radiation Protection and Measurements (NCRP) reference documents.

Time Averaging

Another feature of the exposure guidelines is that exposures may be averaged over certain periods of time with the average not to exceed the limit for continuous exposure. The averaging time for occupational (controlled environment) exposures is **six minutes**, while the averaging time for general population (uncontrolled environment) exposures is **thirty minutes**. To properly apply field measurements to the exposure limits, one must consider the length of time the individual is exposed. For example, with the occupational exposure, during any given six-minute period a worker could be exposed to twice the applicable limit for three minutes as long as they were not exposed at all for the preceding or following three minutes. Similarly, a worker could be exposed at three

times the limit for two minutes as long as no exposure occurs during the preceding or subsequent four minutes.

RESULTS

All of the electric and magnetic field measurements taken with the Holaday HI-4433 STE probe (electric) and EMDEX-II ELF instrument (magnetic) were below their respective limits-of-detection. The only measurable results were obtained for electric fields with the Holiday HI-6005 probe (Table 3). All of these measurements were below the exposure limits for the general public. Further, none of the measurements exceeded 0.1 percent of the applicable limit which indicates that the emissions from this base station pose no threat to employees or the general population who visit or pass through the Tuolumne Meadows Camp Site.

DISCUSSION

The FCC does not require routine assessment of RF fields from base stations, except for roof mounted antennas or where antennas are mounted lower than 10 m above grade. The latter two exceptions do not apply to this site.

Many individuals have expressed concern about possible health risks of RF radiation from these installations, particularly for people residing close to the antennas. In nearly all circumstances, public exposure to RF fields near wireless base stations is far below recommended exposure limits, as found in this HHE. Inside buildings, the RF field intensity will be lower than outside since a substantial fraction of the signal is reflected from the exterior of the building or absorbed when it passes through most building materials. Calculations corresponding to a "worst-case" situation (all transmitters operating simultaneously and continuously at the maximum licensed power) show that to be exposed to levels near the FCC limits for cellular frequencies, an individual

would essentially have to remain in the main transmitting beam (at the height of the antenna) and within a few feet from the antenna. This makes it extremely unlikely that the general public could be exposed to RF levels in excess of these guidelines from cellular base station transmitters.¹¹

Information regarding the health effects associated with exposure to RF radiation can be found at the NIOSH internet site at <http://www.cdc.gov/niosh/emfpg.html> and other internet sites including the Food and Drug Administration (FDA) <http://www.fda.gov/cellphones/>, the FCC <http://www.fcc.gov/oet/rfsafety/>, and the IEEE <http://www.ieeeusa.org/forum/tis/index.html>. These internet sites and their associated links should be used to learn more on this topic, as they are considered to be technically correct and scientifically credible.

CONCLUSIONS

No RF exposure hazards exist from the base-station cellular communication system located in the Tuolumne Meadows Camp Site. This conclusion is based on: (1) all the measurements were well below any RF exposure limits for the general population, (2) the antenna height (78 feet above grade) prevents accidental exposures within a few feet of the antenna, and (3) the geographic layout provides sufficient distance between the base-station antennas and housing units.

RECOMMENDATIONS

There are no recommendations for protective actions; however, we recommend that the readers of this report visit the FCC Frequency Asked Questions website (<http://www.fcc.gov/oet/rfsafety/rf-faqs.html>) to increase their awareness and understanding of the health effects associated with electromagnetic radiation, how it is measured, what research is being conducted in this area, the basis for setting exposure guidelines, and many other issues.

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Date accessed: September 23, 2003.

Table 1. Antenna and Operating Characteristics for Tuolumne Meadows Camp Site	
Antenna Model Number	DB586-XC
Frequency Range	824 - 896 MHz
Number of Channels	5
Max. Effective Radiated Power per Channel	5 Watts
Max. Power per Channel into Antenna	1256 Watts
Antenna Height above ground	78 feet
Maximum Antenna Gain	6 dBd
Down Tilt	0 degrees
Estimated Maximum Power Density*	0.09 microWatts per cm ²

The Institute of Electronics and Electrical Engineers exposure limits for 850 MHz exposures are 567 microWatts per cm² (general public) or 2,833 microWatts per cm² (occupational).

Table 2. Guidelines used for limiting RF exposures from 800 to 900 MHz cellular frequencies					
Cellular frequencies between 800 MHz and 900 MHz	Exposure Limit (Power Density) in milliwatts per square centimeter (mW/cm ²)				
	FCC [§] (1997)	IEEE [†] (1999)	ICNIRP [‡] (1998)	NRPB [#] (1993)	NCRP ^{&} (1986)
General Public*	0.53 - 0.60	0.53 - 0.60	0.40 - 0.45	3.1 - 3.3	0.53 - 0.60
Occupational**	2.67 - 3.00	2.67 - 3.00	2.00 - 2.25	3.1 - 3.3	2.67 - 3.03

Notes

- * These exposure limits are applicable during any consecutive 30 minute exposure period, except for the National Radiological Protection Board (NRPB) limits which do not discriminate between public and occupational exposures.
- ** These exposure limits are applicable during any consecutive six minute exposure period, except for NRPB limits which do not discriminate between public and occupational exposures.
- § U.S. Federal Communications Commission, Washington DC.
- † Institute of Electrical and Electronics Engineers.
- ‡ International Commission on Non-Ionizing Radiation Protection
- # National Radiological Protection Board (United Kingdom). This standard has the same limits for occupational and general public exposure at these frequencies.
- & National Council on Radiation Protection and Measurements.

Table 3. RF Measurement results, Tuolumne Meadows Camp Site, October 22, 2002.

Location	Time of Day	Electric field strength, E, (V/m)*	Power density, S, (microW/cm ²)**	Percent of Limit (general public)#
3029	11:26 a.m.	0.96	0.24	0.045%
3033	11:30 a.m.	0.81	0.17	0.032%
3034	11:32 a.m.	1.04	0.29	0.054%
3007	11:34 a.m.	<i>0.43</i>	0.05	0.009%
3002	11:35 a.m.	<i>0.46</i>	0.06	0.011%
Shower house	11:37 a.m.	<i>0.42</i>	0.05	0.009%
Camp fire	11:38 a.m.	0.55	0.08	0.015%
Ranger station	11:38 a.m.	<i>0.31</i>	0.03	0.006%
3001	11:40 a.m.	0.50	0.07	0.013%
3030	11:42 a.m.	0.59	0.09	0.017%
30301	11:43 a.m.	0.46	0.06	0.011%
3032	11:45 a.m.	0.70	0.13	0.024%
3309	11:47 a.m.	0.59	0.09	0.017%
3308	11:48 a.m.	0.59	0.09	0.017%
Barn	11:50 a.m.	0.59	0.09	0.017%
3037	11:54 a.m.	0.60	0.10	0.019%
“Johnny’s” cabin	11:56 a.m.	0.60	0.10	0.019%
3040	Noon	0.59	0.09	0.017%
3041	Noon	0.59	0.09	0.017%
3045	12:07 p.m.	0.60	0.10	0.019%
3046	12:08 p.m.	0.63	0.13	0.024%
3043	12:10 p.m.	0.59	0.09	0.017%
3058	12:11 p.m.	0.50	0.07	0.013%
3065	12:14 p.m.	<i>0.48</i>	0.06	0.011%
3006	12:15 p.m.	0.59	0.09	0.017%
3056	12:16 p.m.	0.50	0.07	0.013%
Tioga Hillside	12:30 p.m.	1.96		

* Measurements were obtained from the HI-6005 probe. Results in *italics* are below the effective field intensity range of the instrument (0.5 V/m) and could be interpreted as below the detection limit (see Methods Section).

** Power Density (S; microWatts per cm²) estimates were determined by the following equation: $S = E^2 / 377$; where E is the electric field measurement in volts per meter. Note the change in units to microwatts per cm².

Percent of the limit (general public) was based on an assumption of an 800 MHz frequency (exposure limit= 533 microWatts/cm²). A result of 100.0% would indicate that any member of the general public could occupy that space continuously for 30 minutes. Any result below 100.0% indicates that any member of the general public can occupy that space continuously and will not exceed the limit.

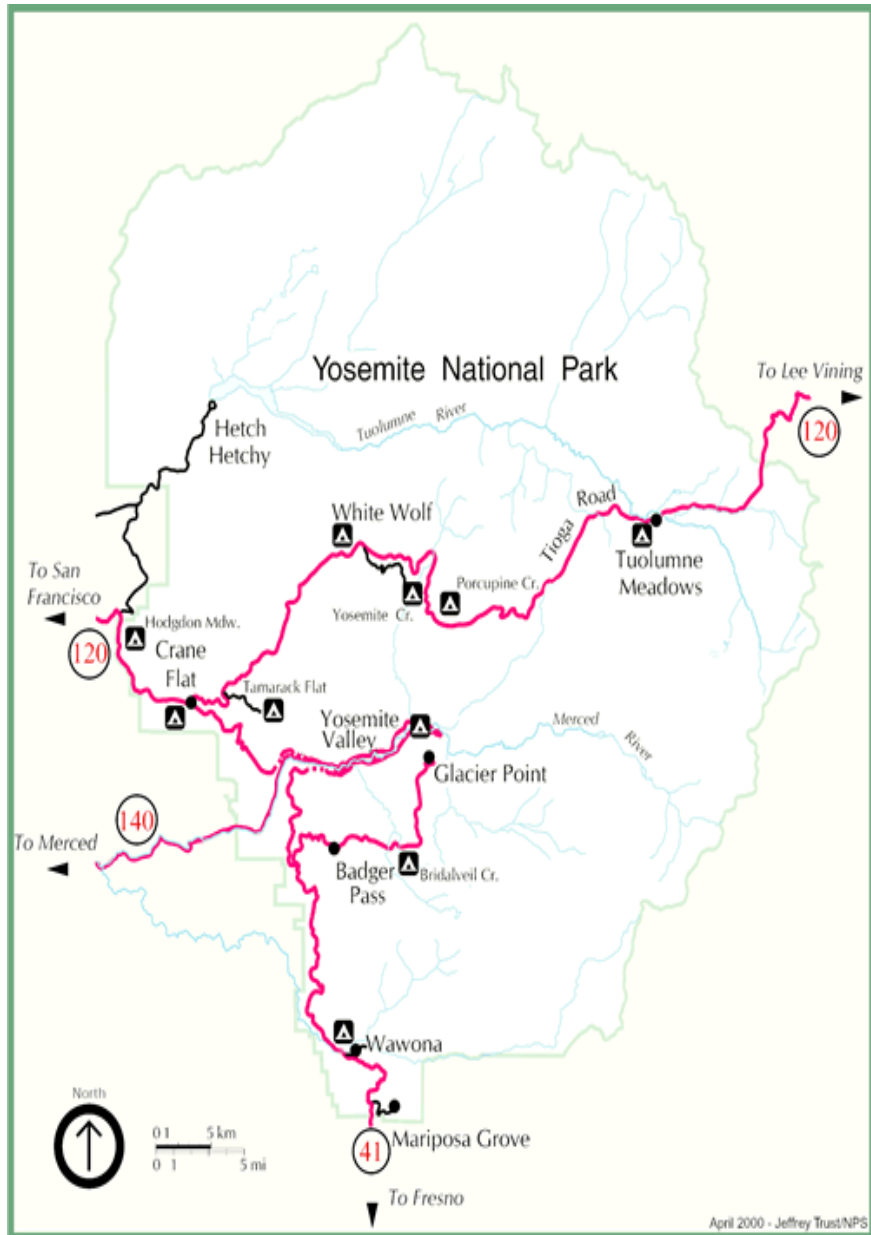


Figure 1. Yosemite National Park.



Tuolumne Meadows Housing Area and Antenna Site

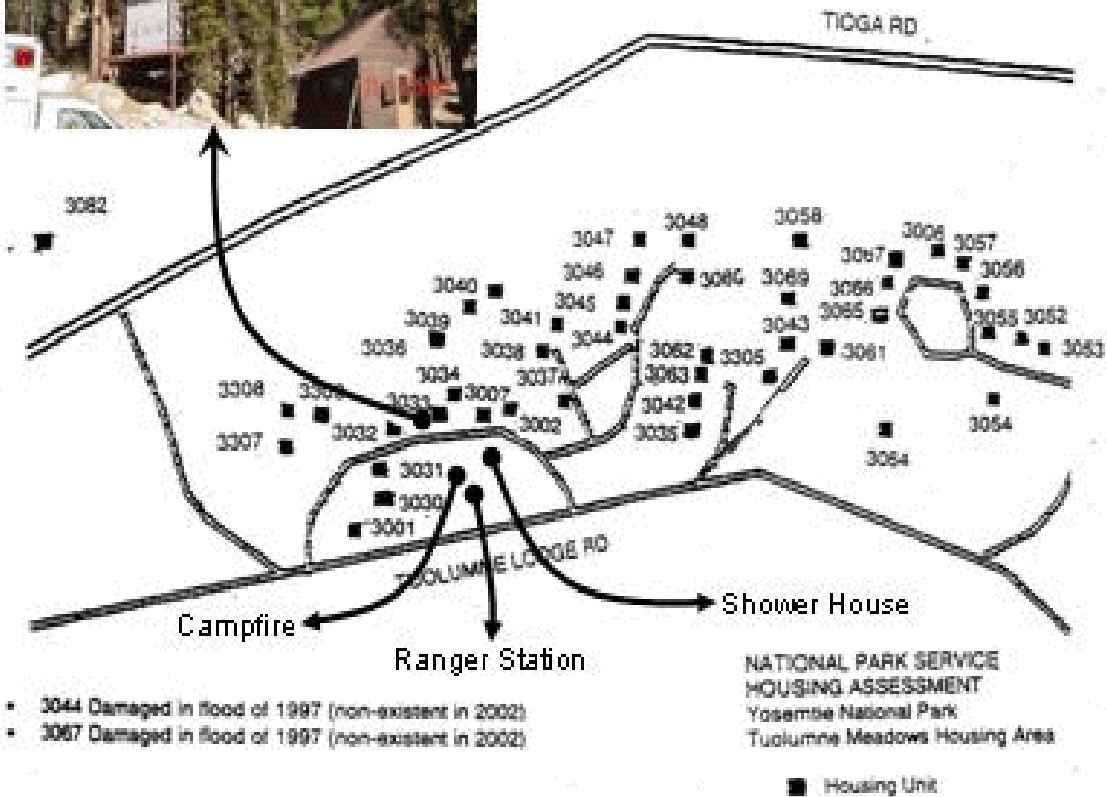
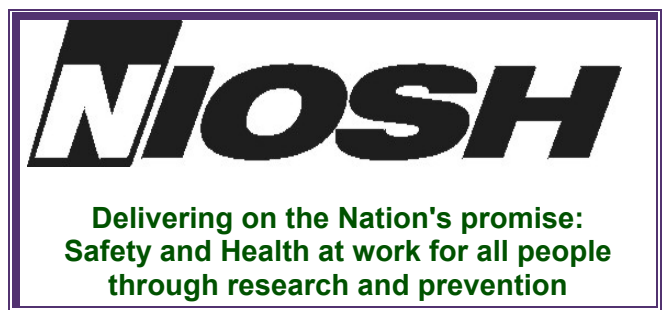


Figure 2. Tuolumne Meadows Housing Area and Antenna Site. October 22, 2003. Map provided by requestor, no scale available.

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