

NEAR-FIELD GEODETIC STUDY OF THE SAN ANDREAS FAULT

G02740

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NEHRP Element(s): I, II

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TECHNICAL ABSTRACT

We surveyed sites of four small-aperture geodetic networks along the San Andreas fault in northern California. Our GPS measurements were combined with line lengths measured in the 1970s and 1980 by the US Geological Survey (USGS) to measure near-fault strain rates, averaged over a few km on either side of the fault. For three of the four networks, we found high near-fault strain rates ( $\gamma = 0.8$  microradian/yr), which could be explained by either a shallow (~5 km) seismogenic (locking) depth for the fault or a typical seismogenic depth of 10-15 km and a compliant layer a few km thick located along the fault. The fourth network had a strain rate about half that of the others, but was poorly fit by a uniform strain model, and the strain estimate may be unreliable. A similar network at Point Arena has a strain rate about 1/3 that of the networks studied here. We interpret the consistently high near-fault strain rates from the San Francisco peninsula north to Bodega Bay as being correlated with the presence of Salinian basement to the west of the fault.

## NON-TECHNICAL ABSTRACT

We studied four geodetic networks along the San Andreas fault from the San Francisco peninsula in the south to Bodega bay in the north. We repeated earlier surveys at each network to extend the time span of data, and determined the strain rate for each network. For three of the four networks we found near-fault high strain rates, which indicate either that the fault is locked near the surface but slipping steadily below about 5 km depth. At Point Arena to the north of these networks, the near-fault strain rate is about 1/3 as high, which can be explained if the fault is locked near the surface and slipping below about 15 km depth, a much more typical result. An alternative explanation for the high near-fault strain rates from the Peninsula to Bodega Bay is that there is a narrow layer of material located in the fault zone with different elastic properties than the surrounding rock. We interpret the consistently high near-fault strain rates from the San Francisco peninsula north to Bodega Bay as being correlated with the presence of Salinian basement to the west of the fault.

## Investigations Undertaken

In the course of this project we made GPS measurements at sites in four small-aperture geodetic networks along the San Andreas fault in northern California (Figure 1). These networks were established by the US Geological Survey (USGS) in the 1970s and early 1980s, and most had not been surveyed since the mid-1980s. The networks typically span about 5 kilometers on either side of the surface trace of the fault. Line length rates of change from these networks were used to measure the near-fault strain rate at the fault, and to distinguish between shallow or deep locking depths. The combined line length and GPS data is sufficient to determine the rates of change of line lengths with a precision of better than 1 mm/yr. With this data we address two important questions: (1) Is there systematic variation along strike in the near-fault strain rate? Variations along strike could be explained by spatial changes in the depth to which the fault is locked in the interseismic period, or by variations in the elastic properties of rocks near the fault zone. (2) How well can a single elastic model fit both the near-field and far-field strain observed geodetically? In future work we will cooperate with Roland Bürgmann of UC Berkeley to develop a three dimensional elastic model (or a series of two dimensional models) to explain both the near field data and the existing far-field data, and expect that this data will improve our knowledge of current slip rates on the major strike-slip faults in the Bay Area.

Work on this project began in May 1996 with site reconnaissance. Most of the site reconnaissance was completed in May and October 1996, along with part of the fieldwork. GPS fieldwork was completed in April 1997, and all GPS data were then analyzed. Detailed reprocessing of the EDM data, combination of the EDM and GPS data, and analysis of the strain derived measured by the networks was completed in late 1997 and early 1998.

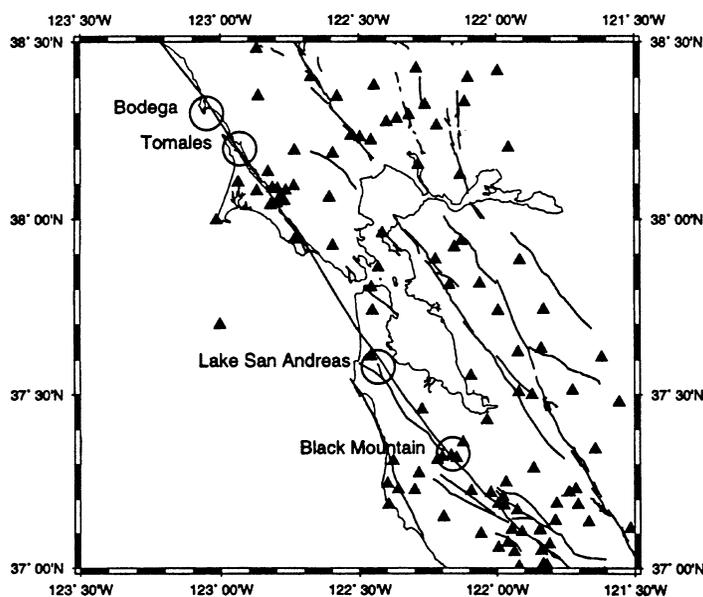


Figure 1. Locations of the small networks being studied in this project. Small black triangles show the locations of regional geodetic sites. Blowups of the two southern networks are shown in Figure 2, and the Bodega and Tomales networks in Figure 3.

### Site Reconnaissance

Because many of the sites needed for this study had not been visited for up to a decade, a significant effort in field reconnaissance was required. The main part of the field reconnaissance was carried out in May 1996, with some additional sites found in October 1996 and April 1997. Existing descriptions for many sites were poorly written or out of date, and markers were found buried under as much as a foot of soil. An appendix to this report contains a complete set of new descriptions for all of the sites used in this study, including up-to-date contacts and permitting info for all sites (Appendix 1).

The great majority of sites were found in good condition, although many had been buried. Because the descriptions as written generally omitted mention of nearby points of reference, considerable time was spent searching for markers with a metal detector. A few markers have not

yet been found, and may be unrecoverable. In some cases we found sites by surveying temporary markers in the probable vicinity of each of the missing marks, and inferring offsets between the temporary marks and the missing survey markers from the GPS coordinate solutions. With the exception of a few sites that clearly have been destroyed, the missing sites are almost certainly buried rather than destroyed; however, from the information available about the missing sites it seems unlikely that they will ever be found except through blind luck.

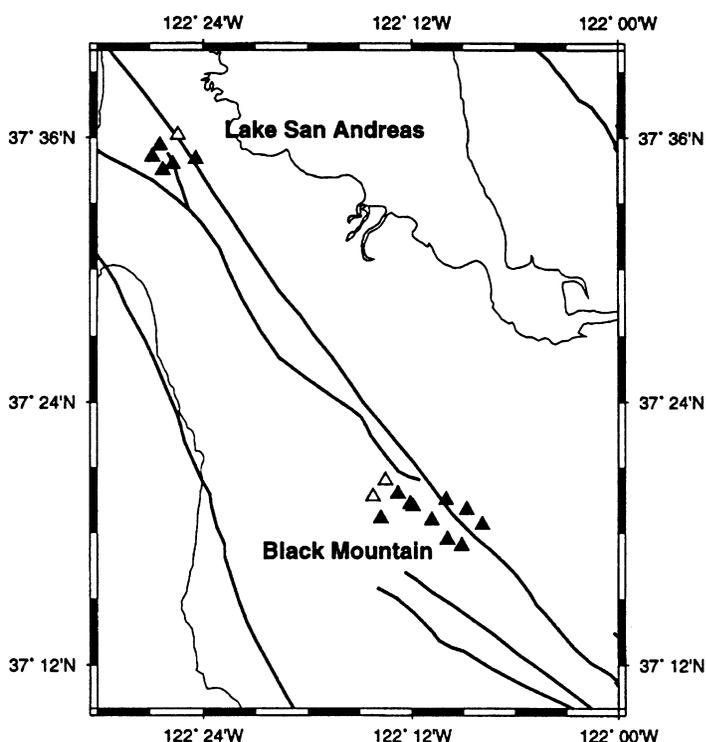


Figure 2. The Black Mountain and Lake San Andreas networks. Solid triangles show sites surveyed with GPS during the course of this project. Open triangles show EDM sites that were not found.

Prieta earthquake. The lines were surveyed one or two times immediately after the earthquake. Line length changes in the five to seven years since the last EDM survey range from near zero to about 30 millimeters. For three lines, the comparison of the GPS and EDM results for the Black Mountain network is clouded by large (>1 meter) discrepancies, which can be explained if a reference mark was used in the EDM surveys. The existing documentation and memories of USGS personnel were not clear on this matter. The lines with large discrepancies were excluded from further consideration, but will be rechecked when we have a chance to visit the sites in the field again.

#### Lake San Andreas Network

The Lake San Andreas network is located on the San Francisco peninsula at the Lake San Andreas reservoir (Figure 2). Of the six sites in the network, five were found and occupied. One site was not found and one had clearly been destroyed.

#### Black Mountain/Radio Facility Network

The Black Mountain/Radio Facility network is the southernmost network in this project (Figure 2), located on the San Francisco peninsula overlooking Palo Alto. One site in the network was destroyed in the 1980s, and a second site could not be visited because the owners could not be contacted to obtain permission. No description could be found for a third site. In addition to the nearly complete occupation of this network, we made simultaneous occupations at several nearby sites that are part of a larger-scale GPS networks. Using these measurements, plus data from two of the Black Mountain network sites that are part of the larger-scale Black Mountain profile, it will be possible to determine vector velocities for all sites in the Black Mountain network, although we have not yet done this.

Most lines in the Black Mountain network were surveyed regularly before 1982, then again in 1989, shortly before the Loma

### *Tomales Bay Network*

The Tomales Bay network (Figure 3) is located on the shores of Tomales Bay, which separates the Point Reyes Peninsula from the mainland. The San Andreas fault runs along the length of Tomales Bay. One site in this network could not be found, because no description had ever been written for it, nor were any precise coordinates available. Ironically, this site was installed after the USGS field crew in 1983 had been unable to locate a historic triangulation marker on the same hill.

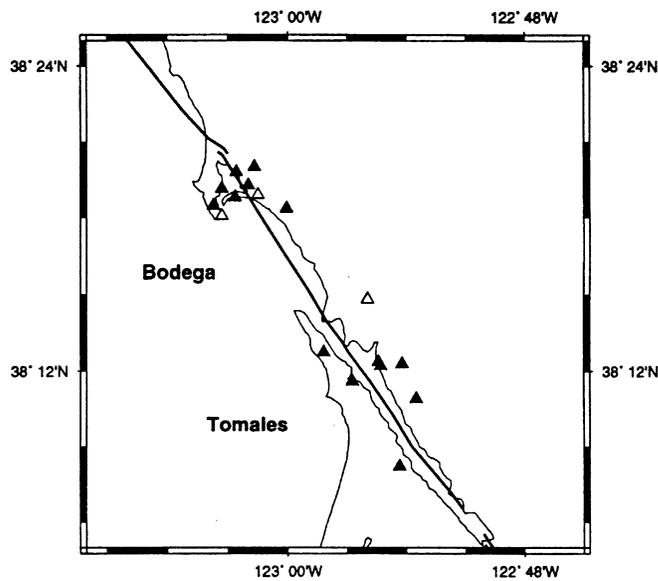


Figure 3. The Tomales and Bodega networks. Solid triangles show sites surveyed with GPS during the course of this project. Open triangles show EDM sites that were not found.

### *Bodega Bay Network*

The Bodega Bay network (Figure 3) is located around Bodega Bay, north of the Point Reyes peninsula. The San Andreas fault runs through Bodega Bay. One site in the network was destroyed in the 1970s when housing development/gold course was built; of the other sites, all but one were found. It should be possible to find the site that was not found (FINBACK), although we were unable to do so despite several trips and even after measuring a temporary mark. While it could have been destroyed, it seems more likely that it was simply buried. The Bodega network was surveyed many times with EDM, beginning in 1967. This network was compromised more than the others by the loss of benchmarks. Most remaining lines surveyed with GPS were at high-angles to the fault.

## Results

### *1. Analysis of GPS data*

We analyzed all data presented in this paper using the GIPSY/OASIS II software (release 4) developed at the Jet Propulsion Laboratory (JPL) [Zumberge *et al.*, 1997; Gregorius, 1996]. We combined the local data with data from regional permanent sites, and estimated solutions while fixing JPL's fiducial-free orbit (estimated without significant *a priori* site position constraints). The solutions were then transformed into ITRF94 using daily transformation parameters provided by JPL. The GPS estimated line lengths for most lines have a precision of about 2 mm. The uncertainty in the GPS line length estimates is comparable to that of the EDM. GPS line lengths were increased by 0.44 ppm based on an empirical scale difference determined by the USGS [Savage ref]. This scale difference, 0.44 mm per kilometer, amounts to no more than a few millimeters on any of the lines used.

## 2. Analysis of the EDM data

We carefully reanalyzed all of the EDM data to ensure consistency, since some of the networks were surveyed with a variety of instruments. The EDM data reduction programs were obtained from USGS, and recompiled and run on our computers. Considerable effort was required to do this, since there was no written documentation for the programs, and none of them actually compiled without modification. In addition, several programs were used at different times for different instruments or file formats, and there was no documentation explaining which program was to be used with which data. With the recompiled programs we were able to exactly reproduce the processed line length files provided to us by USGS.

We then evaluated the effect of coordinate errors in the EDM processing. EDM data reduction is not very sensitive to errors in the assumed a priori station coordinates, except for the corrections for tropospheric refraction. These corrections are sensitive to height errors, and could be important for short lines with significant height differences between the stations. Possible errors in computing tropospheric corrections had been suspected for the Tomales network. We reprocessed all of the EDM data using coordinates derived from our GPS solutions, and found that the mark-to-mark line lengths were identical with those computed using the original coordinates; however, the line lengths projected to horizontal were different in a few cases. The mark-to-mark line lengths were reduced to purely horizontal sea level arc distances, an assumption in the projection is that the line length changes reflect purely horizontal motions. Since the line lengths do not change by very much over time, the projected line length changes are not affected much by errors in the assumed coordinates as long as the same heights were used for reducing all observations. Because it was more convenient to reduce the GPS line lengths to sea level arc distances using the GPS coordinates, we used the EDM lines processed using GPS coordinates. The height is the most critical component of the coordinates.

Several lines in the Lake San Andreas network were found to be very sensitive to errors in the coordinates that had been assumed in the original USGS processing. One example is the line from ERC1 to ERC2, a 1200 meter line with an elevation difference of about 200 meters. For a short, steep line, the projection of the line to horizontal is very sensitive to errors in the relative station heights. For this line, the USGS and our GPS coordinates differed by about 40 meters in height, a consequence of the USGS coordinates having been estimated from a map. The mark-to-mark distances were largely the same regardless of the coordinates used, but the horizontal sea level arc distances changed by up to 10 cm depending on the coordinates used. As a result, we reprocessed all EDM data using coordinates derived from the GPS solutions.

## 3. Strain rates

We used a simple linear fit to estimate the line length rates of change for each line using the GPS and EDM data, and then estimated strain rates for each network from the set of line length rates of change. In a few cases we found large (>1 meter) discrepancies between the GPS and EDM line lengths. Most likely, these discrepancies result from different marks having been used for the GPS and EDM measurements. It was common with EDM networks to use more than one nearby marker at a site because of line-of-sight restrictions. Line length rates of change were then converted to strain rates, and the best-fitting uniform 2D strain tensor was found for each network.

**Table 1.** Strain Rates. The tensor strain rates  $e_{1,1}$ ,  $e_{1,2}$  and  $e_{2,2}$  are estimated from the observed line length rates of change. The three parameters  $\gamma_1$  and  $\gamma_2$  (shears) and  $\Delta$  (areal dilatation) are an equivalent representation of the strain. Units for tensor shears and the areal dilatation are  $10^{-6} \text{ yr}^{-1}$ , and units for the engineering shears are  $10^{-6} \text{ rad yr}^{-1}$ . The reduced chi-squared statistic,  $\chi_v^2$ , is also given. If the uncertainties are realistic,  $\chi_v^2$  should be equal to 1.0.

Network	lines	Tensor Shears			Engineering Shears			$\chi^2_v$
		$e_{11}$	$e_{12}$	$e_{22}$	$\gamma_1$	$\gamma_2$	$\Delta$	
Black Mt	19	$0.51 \pm 0.04$	$-0.07 \pm 0.04$	$-0.29 \pm 0.04$	$0.81 \pm 0.05$	$-0.13 \pm 0.07$	$0.22 \pm 0.06$	2.43
Lake San Andreas	7	$0.40 \pm 0.04$	$0.16 \pm 0.04$	$-0.28 \pm 0.08$	$0.68 \pm 0.08$	$0.31 \pm 0.09$	$0.11 \pm 0.09$	1.21
Tomales	14	$0.07 \pm 0.01$	$0.19 \pm 0.3$	$-0.28 \pm 0.03$	$0.35 \pm 0.03$	$0.38 \pm 0.06$	$-0.21 \pm 0.03$	13.3
Bodega	8	$0.20 \pm 0.16$	$-0.11 \pm 0.10$	$-0.63 \pm 0.10$	$0.84 \pm 0.17$	$-0.22 \pm 0.21$	$-0.44 \pm 0.22$	1.78

Strain rates for each network are summarized in Table 1. The engineering shear strain  $\gamma_1$  corresponds to right lateral shear on a plane striking N45°W, which is rotated only 10-15° from the orientation of the San Andreas fault. As expected, for three of the four of the networks  $\gamma_1$  is the dominant strain component. With the exception of the Tomales network for which several lines are poorly fit by a uniform strain model,  $\gamma_1$  is relatively constant for all networks with a typical value of 0.8 microradian/year. Such a value is comparable to that observed at Point Reyes (Lisowski et al., 1991). The Tomales network appears to be an outlier because of the high misfit, and we are not sure why the strain rate is so different for that network compared to Pointe Reyes immediately to the south and Bodega Bay immediately to the north. A first-order conclusion is that all of the EDM networks from the San Francisco peninsula north to Bodega Bay exhibit high near-fault strain rates, which are roughly a factor of 3 greater than the strain rate averaged over larger areas (Lisowski et al., 1991). North of Bodega Bay, however, the situation is quite different. GPS measurements and a reoccupation of the near-fault EDM network at Point Arena found a much smaller near-fault strain rate, about 1/3 of the rates found for the networks considered in this study (Frey Mueller et al., in press).

Elastic dislocation models predict that the maximum strain rate will be found at the fault, and in the case of a two-dimensional (infinitely long) strike slip fault the maximum shear strain rate is a simple function of the fault slip rate and locking depth (e.g., Savage and Burford, 1973). The near-fault strain rate can then be used to estimate the locking depth of the fault, assuming that the slip rate and elastic properties are known. The locking depth is assumed to be equivalent to the depth to the base of the seismogenic zone, and little if any coseismic slip would occur below the locking depth since below that depth stress is relieved through ductile or plastic deformation. If a uniform elastic half-space is assumed, the locking depth of the San Andreas fault was estimated to be only 5 km for the Point Reyes data, and equivalent values are estimated for all but the Tomales network. A locking depth of about 10 km is preferred for the Tomales network. An alternate model, suggested by Lisowski et al. (1991), calls on lateral inhomogeneities in the elastic properties of the earth to explain the high near-fault strain rates. If the fault zone itself contains material that is significantly more compliant than the surrounding material, strain will be concentrated in the layer of more-compliant material (Rybicki and Kasahara, 1977).

## Discussion

High near-fault strain rates are found between the San Francisco peninsula and Bodega Bay, with the possible exception of Tomales Bay, but the near-fault strain rate further to the north at Point Arena is relatively low. Multiple interpretations of these results are possible. High near-fault strain rates could be due to either the presence of a compliant near-fault zone, or to a shallow locking depth. A lower near-fault strain rate could be due to the absence of a compliant near-fault zone, or to a deeper locking depth. Note that in one case we ascribe the along-strike strain rate variations to variations in locking depth with constant elastic properties, and in the other case to variations in the elastic properties with a constant locking depth. At this point, we cannot distinguish between these two alternatives, although they have very different implications for seismic potential, since the seismic moment potentially available for release scales with the locking depth.

In either interpretation, between Bodega Bay and Point Arena there is either a significant change in the depth to the base of the seismogenic zone, or a significant reduction in the thickness of (or elimination of) a near-fault layer of compliant material. Two plausible explanations for such a change are the maturity of the fault zone (in the south the fault is older than in the north and has slipped a greater distance), or a change in the material properties of the rocks on either side (granitic Salinian basement is found west of the San Andreas fault as far north as Bodega Bay, but is not found further north; Franciscan melange is found east of the fault over the entire area).

We prefer the interpretation that a change in material properties is responsible for the change in near-fault strain rates and locking depths. It is reasonable to suppose that the thickness of a compliant layer near the fault would increase as the fault became older and had undergone greater slip. Unless there is a critical time at which such a layer rapidly forms, we would expect to see a steady increase in the near-fault slip rate from north to south, which is not observed. Instead, we observe an essentially constant near-fault strain rate with a sudden drop north of Bodega Bay. This argues for a change in the material properties, associated with the presence of the Salinian basement to the west of the fault. Here we assume that the strain estimate for Tomales Bay is unreliable due to the extremely high misfit.

Another, more speculative, alternate hypothesis can be formed if we assume that the large misfit for the Tomales network is not due to measurement error, but instead reflects real variations in the strain within the network. During the 1906 earthquake, slip in Tomales Bay was 6-8 meters, 50-100% greater than in the surrounding areas, as determined both by measured surface offsets (Lawson, 1908) and inversion of triangulation data (Thatcher et al., 1997). Thatcher et al. (1997) assumed a constant seismogenic depth of 10 km for the entire fault; if there were significant variations in seismogenic depth within the span of Tomales Bay, constant slip on the fault would be manifested in the geodetic inversion as a variation in slip along strike, with the highest slip being found where the actual seismogenic depth was largest. Such a variation would result in non-uniform strain within the network and a poor fit for a single strain tensor. Because the Tomales network was measured only once with EDM, and a critical site in the north was lost, we have not separated the network into northern and southern parts to test this hypothesis.

## References Cited

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- Rybicki, K., and K. Kasahara, A strike-slip fault in a laterally inhomogeneous medium, *Tectonophysics*, **42**, 127-138, 1977.
- Savage, J. C., and R. O. Burford, Geodetic determination of relative plate motion in central California, *J. Geophys. Res.*, **78**, 832-845, 1973.

## Revised Site Descriptions

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University of Alaska, Fairbanks

revised 4/97 based on fieldwork of 5/96, 10/96, and 4/97.

### 1. Radio Facility Network

Main contact for permission: Mid-Peninsula Regional Open Space District, 415-691-1200 or 415-691-0485. email: mrosd@netcom.com

### 2. Black Mountain Network

Main contact for permission: Mid-Peninsula Regional Open Space District, 415-691-1200 or 415-691-0485. email: mrosd@netcom.com

### 3. Lake San Andreas Network

Main contact for permission: San Francisco Water Department - Land and Resources Protection and Management, for permit and key. Getting a permit takes at least 1 month, and will require a certification of insurance of \$1,000,000. This certification may only be required once for your institution.

Permits: Joe Naras, 415-872-5933

Manager: Ed Stewart, 415-872-5934

Operation: Mark Mueller, 415-871-2022

### 4. Tomales Bay Network

The sites on the Point Reyes peninsula are located in the Point Reyes National Seashore (415-663-1092). The sites on the mainland side are located mostly on private property.

### 5. Bodega Bay Network

Most of the sites are located on private property, except for those on Bodega Head itself, which are located in the Sonoma Coast State Beach (707-875-3483 or 707-875-3382).

1. Radio Facility Network

Main contact for permission: Mid-Peninsula Regional Open Space District, 415-691-1200 or 415-691-0485. email: [mrosd@netcom.com](mailto:mrosd@netcom.com)

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** RF1  
**Stamping:** BO. H. RAD FAC  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 19' 53.1641" N  
**Approx. Long.:** 122° 12' 51.4272" W  
**Permitting Info:** Mid-Peninsula Open Space Preserve 415-691-0485 or  
mrosd@netcom.com.  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded.  
**Location:** Russian Ridge Open Space Preserve, near Radio Facility.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn right and go 1.8 mile to a road left with a mailbox reading "NORTON". Turn left and go uphill, curving to the right and then left, for 0.27 mile to a 4 way intersection. Turn sharp left and uphill and go 0.2 mile to radio repeater. From the radio repeater building, go south ~200 meters to the top of the hill and the station set in a low rock outcrop.

Also found RM1 in another rock outcrop 10 meters to the west.  
Also found RM2 in another rock outcrop 7 meters to the south.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** RF2  
**Stamping:** (obscured)  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 18' 44.7021" N  
**Approx. Long.:** 122° 13' 52.4906" W  
**Permitting Info:** Chris True 415-851-1270.  
**Access:** 4WD vehicle plus 15 minute hike.  
**Security:** May be left unguarded.  
**Location:** Mindego Hill.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Cross Skyline Drive and continue south and west on Alpine Drive for 1.4 miles to a driveway on the right with an anchor on the gate. Gate will be locked. Pass through gate and proceed 1.6 miles to cattle guard and wire gate on left just past cattle guard. Take left through wire gate and proceed 0.45 mile up ridge to the SW to top of grassy knob (Mindego Hill) and station mark set in concrete soil pipe. As of 10/96 it was necessary to stop the vehicle and hike about 15 minutes to the site, a steep hike.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** RF3  
**Stamping:** RF 3  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 19' 46.0879" N  
**Approx. Long.:** 122° 14' 28.0018" W  
**Permitting Info:** Cathy Van Hoorne 415-851-1130.  
**Access:** maybe 2WD vehicle, maybe 4WD depending on rest of road.  
**Security:** May be left unguarded. Not known if cattle are present.  
**Location:** .

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn right and go 2.7 mile to a road left (Langley Road). Turn left on Langley road and go 0.8 mile to a three way fork. Take the rightmost fork, staying on Langley Hill Road (there was a sign as of 5/96) for 0.9 mile to a fork. Go left about 100 feet to gate with label 33, which may be locked. Pass through gate and go 0.4 mile to house, continue 0.1 mile to house and water tank. Go right (south) up hill 0.9 mile to top of hill and fence with wire gate and the end of truck travel. Pass through gate and go down hill south on track road, then right (west) cross-country to top of knob with brush on north side. It is about 1/4 to 1/2 mile from gate to top of hill. There may also be another locked gate on the road.

The occupants of the house, the Van Hoornes, are renters, not the owners. It is necessary to call them far enough in advance that they can contact the owner and get permission. We were never able to contact the owners, so we never occupied this site. It is possible that the Van Hoorne's may have moved since the site was visited, so it is probably best to go to the house first, then try to look up the actual owners.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** RF5  
**Stamping:** RF 5 RESET NCER  
**7.5 min sheets:** Mindogo Hill, CA  
**Approx. Lat.:** 37° 19' 19.0" N  
**Approx. Long.:** 122° 12' 06.0" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-0485 or  
mrobsd@netcom.com.  
**Access:** 4WD vehicle or 0.5 mile hike from 2WD vehicle.  
**Security:** May be left unguarded except on weekends or in nice weather.  
**Location:** Russian Ridge Open Space Preserve.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn right and go 1.45 miles to a side road left with a gate (gate RR01; as of 10/96, the combination was 5500). Pass through gate and go 0.05 mile to a side road left. Turn left and go uphill for 0.55 mile to a saddle between two hills. A trail runs to the top of each hill. Turn right, on foot, and proceed for about 50 meters to the top of the hill and the mark. The mark is set in a rock outcrop to the right of the trail at the highest point of the hill.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Mindego  
**Stamping:** MINDEGO 1947  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 19' 12.397" N  
**Approx. Long.:** 122° 11' 55.020" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-0485 or  
mrosd@netcom.com.  
**Access:** 4WD vehicle or 0.5 mile hike from 2WD vehicle.  
**Security:** May be left unguarded except on weekends or in nice weather.  
**Location:** Russian Ridge Open Space Preserve.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn right and go 1.45 miles to a side road left with a gate (gate RR01). Pass through gate and go 0.05 mile to a side road left. Turn left and go uphill for 0.55 mile to a saddle between two hills. A trail runs to the top of each hill. Follow the trail to the top of the hill to the left (about 50 meters) and the station set in a low rock outcrop at the highest point of the hill

2. Black Mountain Network

Main contact for permission: Mid-Peninsula Regional Open Space District, 415-691-1200 or 415-691-0485. email: [mrosd@netcom.com](mailto:mrosd@netcom.com)

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 7  
**Stamping:** NCER MONITOR NET SKYL-1  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 18' 34.3510" N  
**Approx. Long.:** 122° 10' 52.0730" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrosd@netcom.com.  
**Access:** 2WD vehicle can get within 0.2 mile, 4WD within 50 meters.  
**Security:** May be left unguarded.  
**Location:** Skyline Ridge Open Space Preserve. Local Ranger office phone is  
???-9413.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn left on Skyline Drive and go 0.05 mile to a side road right with a gate (gate SR05). This road is the first road encountered. The gate is often unlocked, but if locked the combo is 9413 as of 10/96. Pass through the gate and go uphill to the Ranger station at old ranch. Go a total of 0.15 mile from Skyline to a fork. Take the left fork (sign points to Ridge Trail (Alternate), Horseshoe Lake and Skyline Parking) and go 0.25 mile to a side road left. Continue straight for 0.05 mile to a fenceline and follow the road left along the fenceline uphill for 0.15 mile to the highest point of the second hill and the end of truck travel. Hike about 50 meters to the left (east) along the high point of the ridge through many small trees to the station set in a rock outcrop. The rock outcrop is at the west end of a 75 cm by 150 cm pile of small boulders.

A tree is located about 5 meters southwest of the mark, causing partial obscuration of the sky.

The Open Space District is very touchy about driving cars up to this site during fire season, so be sure to have a permit with you. There is a great danger of cars touching off fires during the summer and fall. If fire danger is high, it may be necessary to pack in to the site.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 8  
**Stamping:** BL. MT. RAD. FAC.  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 19' 03" N  
**Approx. Long.:** 122° 08' 48" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrosd@netcom.com.  
**Access:** probably 2WD vehicle if dry, otherwise 4WD.  
**Security:** May be left at night, weekdays, bad weather probably OK too.  
**Location:** Black Mountain Radio Facility, Montebello Open Space Preserve.

**To Reach:** To reach from the intersection of El Camino Real and Page Mill Road in Palo Alto, go south on Page Mill Road 9.6 miles to a driveway on the left (Montebello Road) with an electronic gate. A telephone-type keypad is located in a compartment on the left post of the gate. As of 10/96, the combination \*2870 would open the gate. Pass through the gate and go 0.55 mile to a gate (gate MB02) and a chain link gate on the right leading to a large water tank. Pass through gate MB02 (as of 10/96, combination was 5500) and continue on Montebello Road 0.9 miles to a fork. Take the left fork downhill (still Montebello Road) and then uphill for 0.6 miles past a building and radio tower on the left to a second radio building and tower on the right. The station is cemented into a chert outcrop in a cluster of jagged rock outcrops to the right, about 30 meters south of the road.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** PAWT  
**Stamping:** (obscured)  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 19' 30" N  
**Approx. Long.:** 122° 10' 00" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrosd@netcom.com.  
**Access:** 2WD vehicle.  
**Security:** May be left unattended.  
**Location:** Palo Alto Water Tank, Montebello Open Space Preserve.

**To Reach:** To reach from the intersection of El Camino Real and Page Mill Road in Palo Alto, go south on Page Mill Road 9.6 miles to a driveway on the left (Montebello Road) with an electronic gate. A telephone-type keypad is located in a compartment on the left post of the gate MB01. As of 10/96, the combination \*2870 would open the gate. Pass through the gate and go 0.55 mile to a gate (gate MB02, combination as of 10/96 was 5500) and a chain link gate on the right leading to a large water tank and the end of truck travel. As you face the water tanks, climb up the hill to your left, still on the right side of Montebello Road. The station is at the top of the hill, about 50 meters from the chain link gate leading to the water tank. The station disk is located below ground, but is clearly marked at the surface by a loose pipe cap. The stamping has been obscured but the center punch is visible.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 9  
**Stamping:** BMT 9  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 18' 22.4037" N  
**Approx. Long.:** 122° 07' 55.1410" W  
**Permitting Info:** Paul Draper, work phone 408-867-3233 (Montebello Vineyards).  
**Access:** 2WD vehicle from Cupertino; also 2WD vehicle from Page Mill if dry, otherwise 4WD.  
**Security:** May be left unguarded.  
**Location:** Home of Paul Draper, Montebello Vineyards.

**To Reach:** To reach from the intersection of El Camino Real and Page Mill Road in Palo Alto, go south on Page Mill Road 9.6 miles to a driveway on the left (Montebello Road) with an electronic gate. A telephone-type keypad is located in a compartment on the left post of the gate. As of 10/96, the combination \*2870 would open the gate. Pass through the gate and go 0.55 mile to a gate (gate MB02) and a chain link gate on the right leading to a large water tank. Pass through gate MB02 (as of 10/96, combination was 5500) and continue on Montebello Road 0.9 miles to a fork. Take the left fork downhill (still Montebello Road) and then uphill for 2.15 miles to a gate MB09 (as of 10/96, combination was 5500). Pass through the gate and turn immediately right through a double gate into Montebello Vineyards. Turn right on road just after entering Vineyards, and go approximately 0.5 mile to house. Follow road halfway around house and turn left onto a track road leading to rocky point and the station set into a bedrock outcrop. The track road goes through tall grass and the owner requests that you keep your tires within the track marks already there. The vehicle can be turned around near the outcrop. The owner requests that you keep your tire tracks within the track marks already there.

To reach from the intersection of Stevens Creek Road and Foothill Expressway in Cupertino, go southeast on Foothill Blvd., which turns into Stevens Canyon Road. Go a total of 2.25 miles to Montebello Road on the right at the Stevens Creek Reservoir. Turn right and go uphill on Montebello Road for 5.25 miles to the entrance to Montebello Vineyards, and gate MB09 blocking the road. Turn left through the double gate, then immediately right, and proceed as described above.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 10 RH  
**Stamping:** RH  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 17' 24.7902" N  
**Approx. Long.:** 122° 09' 07.9946" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrobsd@netcom.com.  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded at night.  
**Location:** Skyline Drive, beside Upper Stevens Creek County Park.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn left on Skyline Drive and go 3.15 miles to a parking area on the left for the Grizzly Flat Area of Upper Stevens Creek County Park. Walk or drive south along the fenceline parallel to the road about 100 meters to the highest point. Cross the fence and go north about 20 meters to the top of a small, bare knoll and the station. The station is a disk stamped "RH" atop a driven rod, and it is marked by a concrete soil pipe. The top of the concrete pipe has been broken off for some time but as of 5/96 it still marks the location of the station. A reference mark stamped "BMT 10 RM1 1977" is located about 5 meters to the north of the main mark, and is marked by a loose pipe cap. Both marks are 6-8" below the present ground surface. The reference mark has been used in the past for GPS, and both marks have been used for Geodolite measurements.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 10 RM1 1977 (GPS mark)  
**Stamping:** BMT 10 RM1 1977  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 17' 25.0" N  
**Approx. Long.:** 122° 09' 08" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrosd@netcom.com.  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded at night.  
**Location:** Skyline Drive, beside Upper Stevens Creek County Park.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn left on Skyline Drive and go 3.15 miles to a parking area on the left for the Grizzly Flat Area of Upper Stevens Creek County Park. Walk or drive south along the fenceline parallel to the road about 100 meters to the highest point. Cross the fence and go north about 20 meters to the top of a small, bare knoll and the station. The station is a disk stamped "RH" atop a driven rod, and it is marked by a concrete soil pipe. The top of the concrete pipe has been broken off for some time but as of 5/96 it still marks the location of the station. A reference mark stamped "BMT 10 RM1 1977" is located about 5 meters to the north of the main mark, and is marked by a loose pipe cap. Both marks are 6-8" below the present ground surface. The reference has been used in the past for GPS, and both marks have been used for Geodolite measurements.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** BMT 11  
**Stamping:** INSERP  
**7.5 min sheets:** Mindego Hill, CA  
**Approx. Lat.:** 37° 17' 42.4982" N  
**Approx. Long.:** 122° 09' 56.4468" W  
**Permitting Info:** Mid-Peninsula Open Space District 415-691-1200 or  
mrosd@netcom.com.  
**Access:** 2WD vehicle plus 7.5 minute hike.  
**Security:** May be left unguarded.  
**Location:** Skyline Ridge Open Space Preserve.

**To Reach:** To reach from Palo Alto, drive south on Page Mill Road to the intersection of Skyline Drive (SR35). Turn left on Skyline Drive and go 2.4 miles to a paved driveway with a locked gate (gate SR01). It is not necessary to pass through the gate with a vehicle but it will save a few minutes walk. Go through the gate and go about 0.05 mile to the end of truck travel. Hike up the hill on the left to the top of the hill and the station. There is no trail and the upper part of the hill is quite steep. The station is located at the highest part of the hill near the fenceline. The station mark is about 8" below the surface of the ground between three irregular masses of concrete with pipes which might be suitable for placing tripod legs.

### 3. Lake San Andreas Network

Main contact for permission: San Francisco Water Department - Land and Resources Protection and Management, for permit and key. Getting a permit can take as long as one month, and may involve an extreme exercise in risk management bureaucracy.

Permits: Joe Naras, 415-872-5933

Manager: Ed Stewart, 415-872-5934

Operation: Mark Mueller, 415-871-2022

\*\*\*\*\*

**Station Name:** ERC 1  
**4 Character ID:** ERC1  
**Stamping:** ERC 1  
**Agency/Type of Mark:** USGS disk  
**NGS PID:** none  
**USGS Quad:** Montara Mountain, CA 7.5'  
**Location:** San Andreas Lake  
**Position:** 37° 35' 1.2167"N 122° 24' 27.6111" W  
**Height:** 167.60 m  
**Permitting Info:** San Francisco Water Department, Joe Naras, 415-872-5933  
**Access:** 2WD vehicle  
**Security:** May be left unguarded  
**Monument:** Brass disk in bedrock  
**Stability:** Good  
**Magnetic Declination:** 16° E

**To Reach:** From the intersection of Hwy 280 and Sand Hill Road in Menlo Park, go north on Hwy 280 for 15.3 miles. Take the Millbrae offramp and go 0.15 miles to a corner. Turn left (west) and go under the freeway and onto a dirt road through a fence. The key for this gate and the following gates are available from the San Francisco Water Department. Follow the dirt road into the San Francisco Water Department reserve for 0.55 miles. On the left (east) just before a sharp bend is a rock quarry. Go through the gate on the left and go 0.1 miles to the southwest side of the quarry and a concrete pier that protrudes 2.5 feet above the ground. The pier is close to a rock wall of the quarry. The pier is about 18 inches in diameter and has a 3 inch pipe cemented in the center. The station mark is about 2 feet east of a 10 foot dropoff, about 25 feet east of the concrete pier. There are a lot of trees around.

\*\*\*\*\*

**Station Name:** ERC 2  
**4 Character ID:** ERC2  
**Stamping:** (obscured)  
**Agency/Type of Mark:** USGS disk  
**NGS PID:** none  
**USGS Quad:** Montara Mountain, CA 7.5'  
**Location:** San Andreas Lake  
**Position:** N W  
**Height:** m  
**Permitting Info:** San Francisco Water Department, Joe Naras, 415-872-5933  
**Access:** 2WD vehicle  
**Security:** May be left unguarded  
**Monument:**  
**Stability:**  
**Magnetic Declination:** 16° E

**To Reach:** From the intersection of Hwy 280 and Sand Hill Road in Menlo Park, go north on Hwy 280 for 15.3 miles. Take the Millbrae offramp and go 0.15 miles to a corner. Turn left (west) and go under the freeway and onto a dirt road through a fence. The key for this gate and the following gates are available from the San Francisco Water Department. Follow the dirt road into the San Francisco Water Department reserve for 0.8 miles to a small dam and a fork. Take the right fork (west) and proceed for 0.2 miles. Turn right (north) and go through a locked gate. Follow the road for 1.65 miles to a 3-way intersection. Take the left fork (south) and follow dirt road for 0.3 miles towards hill ridge. On the right (north) side of the road is a telephone pole 8-10 feet higher than the road. On the same side of the road is a 3 inch diameter pipe that projects 18 inches above the ground and is 4 feet higher than the road bed.

The mark is located about 7 feet northwest of the telephone pole, and about 30 feet north of the pipe. Two reference marks (RM1 and RM2) were found to the southwest of the main mark.

\*\*\*\*\*

**Station Name:** ERC 4  
**4 Character ID:** ERC4  
**Stamping:** ERC 4  
**Agency/Type of Mark:** USGS disk  
**NGS PID:** none  
**USGS Quad:** Montara Mountain, CA 7.5'  
**Location:** San Andreas Lake  
**Position:** N W  
**Height:** m  
**Permitting Info:** San Francisco Water Department, Joe Naras, 415-872-5933  
**Access:** 2WD vehicle  
**Security:** May be left unguarded  
**Monument:** Brass disk in bedrock  
**Stability:** Excellent  
**Magnetic Declination:** 16° E

**To Reach:** From the intersection of Hwy 280 and Sand Hill Road in Menlo Park, go north on Hwy 280 for 15.3 miles. Take the Millbrae offramp and go 0.15 miles to a corner. Turn left (west) and go under the freeway and onto a dirt road through a fence. The key for this gate and the following gates are available from the San Francisco Water Department. Follow the dirt road into the San Francisco Water Department reserve for 0.8 miles to a small dam and a fork. Take the right fork (west) and proceed for 0.2 miles. Turn right (north) and go through a locked gate. Follow the road for 1.65 miles to a 3-way intersection. Take the right fork (north) and follow dirt road for 1.4 miles. On the right (east) side of the road is a path leading into thick underbrush. On the same side of the road and two feet higher than the road is a 3 inch diameter pipe that projects 12 inches above the ground. The 3 inch diameter pipe is about 7 feet from the path.

The mark is located about 50 feet east of the road.

Beware of poison oak in this area!

\*\*\*\*\*

**Station Name:** ERC 5  
**4 Character ID:** ERC5  
**Stamping:** ERC 5  
**Agency/Type of Mark:** USGS disk  
**NGS PID:** none  
**USGS Quad:** Montara Mountain, CA 7.5'  
**Location:** San Andreas Lake  
**Position:** N W  
**Height:** m  
**Permitting Info:** San Francisco Water Department, Joe Naras, 415-872-5933  
**Access:** 2WD vehicle  
**Security:** May be left unguarded  
**Monument:** Brass disk in bedrock  
**Stability:** Excellent  
**Magnetic Declination:** 16° E

**To Reach:** From the intersection of Hwy 280 and Sand Hill Road in Menlo Park, go north on Hwy 280 for 15.3 miles. Take the Millbrae offramp and go 0.15 miles to a corner. Turn left (west) and go under the freeway and onto a dirt road through a fence. The key for this gate and the following gates are available from the San Francisco Water Department. Follow the dirt road into the San Francisco Water Department reserve for 0.8 miles to a small dam and a fork. Take the right fork (west) and proceed for 0.2 miles. Turn right (north) and go through a locked gate. Follow the road for 1.65 miles to a 3-way intersection. Take the right fork (north) and follow dirt road for 1.45 miles to an intersection. Turn left (west) and follow road for 1.90 miles to an intersection. Take left fork (east) for 0.65 miles to a small knoll on the right (west) side of the road.

The mark is located about 20 feet west of the road, and 10 feet higher than the road bed. The disk is clamped to a driven rod inside an 8 inch diameter transite pipe. The pipe is set flush with the ground surface.

Beware of poison oak in this area!

4. Tomales Bay Network  
Tomales Pizza, Tomales 878-2222

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Foster  
**Stamping:** FOSTER 1857 1929  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 08' 12.44" N  
**Approx. Long.:** 122° 54' 22.12" W  
**Permitting Info:** Point Reyes National Seashore, John Dell'Osso 415-663-1092. C. W. and Wyleen Lobaugh, "L" Ranch, 415-669-1227.  
**Access:** 2WD vehicle plus 15 minute hike, of 4WD vehicle.  
**Security:** May be left unguarded, may need fence for cattle.  
**Location:** Atop a hill on Point Reyes Peninsula.

**To Reach:** To reach from Inverness, go 2.5 miles north and west on Sir Francis Drake Highway toward the Point Reyes Lighthouse to a road fork. Take the right fork, Pierce Point Road, toward Tomales Bay State Park. Go 1.3 miles to a fork just past the turnoff for Tomales Bay State Park. Take the right fork, Duck Cove/Marshall Beach Road, and go 1.05 miles to a cross road. At this point a ranch house and other buildings will be visible on the left, and the Lobaugh family who lease this land should be notified before entering the property. Turn right and go 0.2 miles to a locked gate. As of 4/97, the combo on the gate was 1296. Pass through the gate and drive (4WD) or hike to the top of the hill on the left. Reference mark 5 was found at approximately the highest point of the hill, a standard RM disk cemented into a boulder projecting 6". The main mark is located 36.71 meters toward 26.25° (true) from RM5, a few inches below ground level in the middle of a fallen barbed wire fence. Three iron stakes were driven into the ground around the mark. The main mark is located about 20 meters WSW of a lone cypress tree. High winds are common so sandbags are needed. A barbed wire fence is also required since cows are often in the area.

RM2 is a drill hole in a boulder located 9.80 meters toward 90° (true)

RM4 is a standard RM disk stamped FOSTER 1857 NO 4 1929, located 21.775 meters toward 60° (true). It is located near the lone cypress tree described above.

The land is owned by the National Seashore, and leased by the Lobaugh family (C. W. and Wyleen Lobaugh, 100 Pierce Point Road, Point Reyes, CA 94956; tel. 415-669-1227; barn 415-669-7115). Permission should be obtained from both. The National Seashore does not want any vehicles to go where there are not already roads or tracks.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Halleck  
**Stamping:** HALLECK 1929  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 12' 17.82" N  
**Approx. Long.:** 122° 54' 14.25" W  
**Permitting Info:** Gene Poncha 707-878-2323 or 707-878-2209.  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded but needs fence for cattle.  
**Location:** 3 miles south of Tomales, CA.

**To Reach:** To reach from the Post Office in Tomales, go southwest on State Highway 1 for about 1 mile to the bridge over Walker Creek at mile 44.50 (Marin). Just past the bridge, turn left onto a private drive with a gate (the gate should be open). Just after the gate, take the right fork uphill onto a winding road along the ridge top. Go 1.9 miles past two houses to a wooden gate. Pass through the gate and go straight for about 500 feet to the station. The station mark is slightly west of the extension of the fenceline. The station is a standard disk cemented into a rock outcrop or boulder in the middle of a pasture. A barbed wire fence will be required to keep away cattle.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Mershon RM 5  
**Stamping:** MERSHON NO 5 1856 1921  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 10' 54.15" N  
**Approx. Long.:** 122° 54' 04.774" W  
**Permitting Info:** Blake's Landing Farms (Albert Straus) 415-663-1211 or 415-663-1194 (unconfirmed).  
**Access:** 4WD vehicle. 2WD vehicle can get within about 0.25 mile in dry weather.  
**Security:** May be left unguarded.  
**Location:** 1 mile north of Marshall, CA.

**To Reach:** To reach from Marshall, go 2 miles north on State Highway 1 to a driveway on the right with sign for Blake's Landing Farms, 22188 Hwy 1. Turn right and go 0.2 miles to a large red barn. Pass to the left of the barn and turn right around the back side of the barn, and then right again to a wire gate. Pass through the wire gate and follow the fenceline uphill for 0.05 mile to a fork. Take the left fork, uphill, for 0.1 miles to a fork. Take the left fork uphill for 0.15 miles on a track road to a fence with a gate. Turn right at the fence and go 0.05 mile along the fenceline to the end of truck travel about 30 meters north of a corner in the fence. From this point, RM6 is located about 10 meters to the west of the fence, downhill, and RM5 is located about 25 meters east of the fence, slightly uphill. Both RMs are standard RM disks set into boulders. The station mark was not found.

**NOTE:** Make measurements on RM5.

\*\*\*\*\*

**Station Name:** Oyster  
**4 Character ID:** OYST  
**Stamping:** OYSTER 1983  
**Agency/Type of Mark:** NCER disk on driven rod  
**NGS PID:** (none)  
**USGS Quad:**  
**Location:** "Hamlet Acres", east shore of Tomales Bay  
**Position:** 38° 12' 21.8" N 122° 55' 27.59" W  
**Height:** 15.24 m  
**Permitting Info:** none  
**Access:** 2WD vehicle plus <5 minute hike  
**Security:** May be left unguarded for short periods of time  
**Monument:** driven rod  
**Stability:** satisfactory  
**Magnetic Declination:** 17° E

**To Reach:**

To reach from the Post Office in Tomales, go south on State Highway 1 for 3.25 miles to milepost 42.36 (Marin) at a low point in the road, across from a house with a sign --Hamlet Acres--. Park in the wide spot on the west (bay) side of the highway, and walk 100 feet toward the bay, then bear left (southward) on a trail up a hill to a wide flat area gently sloping up to the west. Continue southward past an abandoned shack, for a total of about 0.1 mile from the highway, to a fence line, and the station 7 meters (true) north of a fence post. The mark is 19 meters toward 120° (magnetic) from the highest point of the hill, and 38 meters toward 170 (magnetic) from the abandoned shack. The mark is located at the base of a bush that as of 4/97 was about 4 feet high.

From the mark, the Hamlet Acres house is at an azimuth of 15° (magnetic). Looking south toward Nick's Cove from the mark, to the right of the cliff you can see two white houses. Away from the mark, either more or fewer houses will be visible.

The marker is a disk clamped onto a driven rod, enclosed in a cylindrical tube capped with a lid.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Preston 2 RM 1  
**Stamping:** PRESTON 2 NO 1 1906 1921  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 12' 13.77" N  
**Approx. Long.:** 122° 55' 18.48" W  
**Permitting Info:** none  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded for short periods of time.  
**Location:** 50 meters west of State Highway 1 at mile 42.00 (Marin).

**To Reach:** To reach from the Post Office in Tomales, go south on State Highway 1 for 3.5 miles to milepost 42.00 (Marin) at the summit of the second hill SE of Hamlet and the end of vehicle travel. The station is located about 50 meters west of the highway on the far side of a prominent outcrop of boulders. The station mark was not found, but two reference marks were found. PRESTON 2 NO 1 1906 1921 is a standard disk set into a large boulder west of the highest point of the outcrop. PRESTON 2 1906 NO 2 1985 is set into an outcrop about 5 meters toward 53° (true) from RM 1.

Beware of poison oak.

**NOTE:** Make observations at RM1. The setup is difficult with a tripod, but can be done. A spike mount may be easier.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Tomales Bay  
**Stamping:** Unstamped bolt with a cross cut into it  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 10' 54.47" N  
**Approx. Long.:** 122° 56' 45.58" W  
**Permitting Info:** Point Reyes National Seashore 415-663-1092  
**Access:** 2WD vehicle plus 5 minute hike.  
**Security:** May be left unguarded.  
**Location:** 3 miles southeast of Tomales Point.

**To Reach:** To reach from Inverness, go 2.5 miles north and west on Sir Francis Drake Highway toward the Point Reyes Lighthouse to a road fork. Take the right fork, Pierce Point Road, toward Tomales Bay State Park. Go 8.1 miles and stop at the high point of the road. Station is located at the highest point of the hill to the right. The station mark is a round bolt with a cross carved into it, set into the top of a 18" square concrete pier which is about 4 feet high. A VABM disk stamped VA677 is located in a corner of the pier. NOTE: The station mark is the unstamped bolt with a cross carved in it, not the VABM disk.

Tripod setup is impossible, but a spike mount works well. It will be necessary to fasten down the legs of the spike mount since high winds are common.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Tomales Point  
**Stamping:** TOMALES POINT 1856 1929  
**7.5 min sheets:** Tomales, CA  
**Approx. Lat.:** 38° 12' 44.74" N  
**Approx. Long.:** 122° 58' 13.30" W  
**Permitting Info:** Point Reyes National Seashore 415-663-1092  
**Access:** 2WD vehicle plus 45 (2.2 mile) minute hike.  
**Security:** May be left unguarded.  
**Location:** 1 mile southeast of Tomales Point.

**To Reach:** To reach from Inverness, go 2.5 miles north and west on Sir Francis Drake Highway toward the Point Reyes Lighthouse to a road fork. Take the right fork, Pierce Point Road, toward Tomales Bay State Park. Go 9.0 miles on Pierce Point road to the turnoff for historic Pierce Point Ranch and the end of vehicle travel. Take the trail from the parking area toward Tomales Point for about 2 miles (45 minutes) to a hill on the right. The station is located on the far side of the hilltop from the trail, on the highest of a group of rocky knolls. The station is a standard disk set into a rock outcrop about 4 feet west of the highest point of the knoll. A handheld GPS unit will be the most effective way of navigating to the site.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Point Reyes NCMN  
**Stamping:** POINT REYES NCMN 1981  
**7.5 min sheets:** Drake's Bay, CA  
**Approx. Lat.:** 38° 06' 13" N  
**Approx. Long.:** 122° 56' 11" W  
**Permitting Info:** Coast Guard Communications Station 415-669-2002  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded.  
**Location:** San Francisco Coast Guard communications station.

**To Reach:** To reach from Inverness, go 2.5 miles north and west on Sir Francis Drake Highway to a fork. Take the left fork and go westerly 1.0 mile to a side road left with a sign reading "Mt. Vision". Continue straight for 1.9 miles to a side road right with a sign "Coast Guard Communication Station". Turn right and pass through several cattle guards, going a total of 1.3 miles to the Coast Guard building on the right. The station is a disk set in concrete in the asphalt parking lot behind the building, about 20 feet southeast of a basketball hoop. Sandbags are necessary because high winds are likely.

RM2 is located 49.987 meters toward 257° (true), on the other side of a fence line. Due to construction of a new garage at the Coast Guard site, the main mark is no longer suitable for extended GPS observations. RM2 is suitable for extended GPS observations, but may need a barbed wire fence due to the presence of cattle.

Past contacts have been Chief Fellows, Master Chief Mize, Chief Shofner, and Lt. Cmdr. Leonard Ritter.

5. Bodega Bay Network

Distances south on Highway 1 from Bay Flats Road.

Turnoff for Salmon	0.35 mi. (<100 m south of MP 10.10)
Visitor Information Center	0.5 mi.
Site 0411	0.9 mi. (at Bodega Coast Inn)
Turnoff for Tide	1.0 mi. (20 m south of driveway for new fire station)
N. Harbor Way	1.25 mi.
S. Harbor Way	1.65 mi.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Bodega  
**Stamping:** BODEGA 1855 1929  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 18' 22.57" N  
**Approx. Long.:** 123° 00' 02.45" W  
**Permitting Info:** George Bottarini, 707-795-3068. Access to the locked gate is through Bodega Farms: San Francisco office (Mr. Gordon), 415-921-1355, farm 707-875-2273, fax 707-875-9837.  
**Access:** 2WD vehicle plus 20 minute hike, or 4WD.  
**Security:** May be left unguarded. Check into presence of cattle.  
**Location:** Bottarini Ranch, north of Estero Americano.

**To Reach:** To reach from the Post Office in Valley Ford, go about 3.7 miles west and north on State Highway 1 to Estero Lane on the left at milepost Sonoma 6.00. Go 2.2 miles south and west on Estero Lane to a locked gate that blocks the road. The gate has a "B" symbol on it. As of 4/97, the combination was 5381. Pass through the gate and go about 50 meters to a track road on the left. Follow the track road uphill about 75 meters to the saddle in the ridge, then bear right on a dirt track up the ridge line for roughly 0.6 miles to a barbed wire fence (there is only a dim track of a road). Pass through the gate and continue cross country to the highest point of the last hill and the station in the ruins of a fenced enclosure. The station mark is located about 4" below ground level 9 meters toward 170° magnetic from a solitary wooden post about 4 feet high. The station disk is cemented into a rock.

Reference Mark 1 is located 21.9 meters toward 155° (true).

An azimuth mark is located near the top of the hill to the northeast of the station mark.

Access through the gate must be obtained through Bodega Farms. The mark itself is on the Bottarini Ranch, and permission must be obtained from George Bottarini. The mark can be accessed without specific permission from Bodega Farms, but it will be necessary to hike from the gate. The mark is about a 20 minute hike from the gate.

**NOTE:** Also make observations on RM1. RM1 is located 21.9 meters toward 155° (true).

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Bodega Head 2  
**Stamping:** BODEGA HEAD 2 1906 1929  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 18' 28.25" N  
**Approx. Long.:** 123° 03' 44.23" W  
**Permitting Info:** Sonoma Coast State Beach 707-875-3483 or 707-875-3382.  
**Access:** 2WD vehicle plus 7.5 minute hike.  
**Security:** May be left unguarded.  
**Location:** Bodega Head.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats Road in Bodega Bay, go north 0.5 mile to a side road left, East Shore Road, with a sign pointing the way to Bodega Head. Turn left and go 0.3 mile downhill to an intersection with Bay Flats Road. Turn right and go 3.25 miles to a fork. Take the right fork and go 0.2 miles to a parking area and the end of vehicle travel. Take the trail at the north end of the parking area toward the Horseshoe Cove overlook and follow the trail uphill for 0.4 mile to a saddle and a sign. From the sign, hike cross country to the highest point of the hill to the south and the station mark. The station mark is a standard disk cemented into a boulder 6" below the ground surface at the highest point of the hill.

**NOTE:** BODEGA HEAD 1855 is a brass peg with a carved cross set into the top of an irregular mass of concrete, located 1.65 meters toward 21° (true) from BODEGA HEAD 2.

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**Station Name:** Doran  
**4 Character ID:** DORA  
**Stamping:** DORAN 1957  
**Agency/Type of Mark:** USC&GS Triangulation Disk  
**NGS PID:**  
**USGS Quad:** Bodega Bay, CA 7.5'  
**Location:** Doran Beach Park, Bodega Bay  
**Position:** 38° 18' 48" N 123° 02' 40" W  
**Height:** 5.36 m  
**Permitting Info:** none. Located in Doran Beach Park  
**Access:** 2WD vehicle  
**Security:** Must be guarded at all times  
**Monument:** Disk in 10 inch square concrete monument  
**Stability:** Good  
**Magnetic Declination:** 17° E

**To Reach:**

Station is located 1.3 miles south of the village of Bodega Bay, 0.7 miles southwest of highway 1, in Doran Park, on the sand spit between Bodega Harbor and Bodega Bay, on a sand dune about 12 feet above mean high water, about 190 feet north of the mean high water line and 141 feet south of centerline of road, on highest part of dune. Mark is a standard triangulation disk stamped DORAN 1957 set in top of square concrete monument. The station is about 100 feet west of a stand of trees at the west end of the Cypress Day Use area. Parking is available about 100 yards to the west across from the Shell Campground.

To reach station from the town of Bodega Bay, proceed in a southerly direction along State Highway to paved road right (west) leading to Doran Park and the Coast Guard station. Proceed in a southerly and westerly direction up grade, then down for 1.2 miles to the entry fee booth for Doran Park. From the entry fee both, continue 0.6 miles to the station on the left, about 140feet from the centerline of the road. Station is on left (south) on highest point of low sand dune.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Gaffney Reset  
**Stamping:** GAFFNEY RESET 1960  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 19' 08.84129" N  
**Approx. Long.:** 123° 03' 17.45048" W  
**Permitting Info:** none  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded at night.  
**Location:** Atop a small sandy knoll on Bodega Head.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats Road in Bodega Bay, go north 0.5 mile to a side road left, East Shore Road, with a sign pointing the way to Bodega Head. Turn left and go 0.3 mile downhill to an intersection with Bay Flats Road. Turn right and go 2.1 miles to a side road sharp right. Turn onto this road and park. The station is located on the low sandy knoll to the west of this side road. The station mark is a USE disk stamped GAFFNEY RESET 1960 set in the top of a 16 inch irregular mass of concrete which projects 2". It is 118 feet northwest of the centerline of Bay Flats Road, and 86 feet northwest of a power pole.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** HPGN 0411  
**Stamping:** HPGN 0411 1990  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 19' 26" N  
**Approx. Long.:** 123° 02' 16" W  
**Permitting Info:** none  
**Access:** 2WD vehicle.  
**Security:** Must be guarded at all times.  
**Location:** Between State Highway 1 and the Holiday Inn parking lot, Bodega Bay, CA.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats Road in Bodega Bay, go south to milepost 9.51 (Sonoma) and the station on the right. More convenient access is obtained by continuing to the next side road right at the Holiday Inn. Turn right and go 0.05 mile to a side road right. Turn right and go 0.05 mile to the entrance to the Holiday Inn parking lot. Proceed to the east edge of the parking lot and park. The station is a 2.5" aluminum disk inside a 6" aluminum access cover, located on the ridge between the parking lot and the highway, about 11 feet west of the westerly edge of the highway.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Knob Reset  
**Stamping:** KNOB RESET 1971  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 19' 13.39" N  
**Approx. Long.:** 123° 02' 04.14" W  
**Permitting Info:** Ed and Jane Vail, 707-875-3711.  
**Access:** 2WD vehicle.  
**Security:** May be left unguarded overnight, or daytime if the Vail's are home.  
**Location:** between 104 and 109 Poppy Court, Bodega Harbour Estates.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats road in Bodega Bay, go south on Highway 1 for 1.2 miles to a side road left, North Harbour Way. Turn left and go southerly and uphill for 0.2 mile to a T intersection with Sea Way. Turn left and go northerly for 0.05 mile to a side road left, Cypress Loop. Turn left and go westerly 0.05 mile to a side road left, Poppy Court. Turn left and go southwesterly 0.1 mile to the end of the road, and the end of truck travel. The property owners live in 104 Poppy Court, the house to the left of a vacant lot. The marker is about 50 meters southeast of the end of the road, across the grassy open lot. It is just beyond the grassy area where the hill begins to drop off. The marker is located about 15' northeast of a sewer top set in concrete. It is a 3" brass disk set in a 10" square block of concrete.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Salmon  
**Stamping:** SALMON 1967  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 19' 48.72176" N  
**Approx. Long.:** 123° 02' 34.60767" W  
**Permitting Info:** unknown – check at houses up the driveway  
**Access:** 2WD vehicle.  
**Security:** Must be guarded at all times.  
**Location:** On a hill overlooking Bodega Bay.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats road in Bodega Bay, go south on Highway 1 for 0.35 miles to a driveway on the left, opposite two shops (Gourmet Au Bay and Patrick's Salt Water Taffy). The driveway is located <100 meters south of milepost 10.10. The next left after this driveway is for the Inn at the Tides. Turn left and go 0.1 mile uphill, curving right and then left, to a clearing on the left, immediately past the left bend in the road. A concrete drain about 2 feet square is visible opposite the clearing. The mark is located at the edge of the cleared area 12 m from the centerline of the road. It is located 14 m toward an azimuth of 256 magnetic from the concrete drain. The mark is located 7 meters south-southeast of abandoned concrete stairs, which are located about 16 meters from the centerline of the road. In April 1997, the mark was found covered by about 1 inch of soil in a large clump of grassy bushes. The vegetation immediately around the mark was cleared.

\*\*\*\*\* STATION DESCRIPTION \*\*\*\*\*

**Station Name:** Tide  
**Stamping:** TIDE 1967  
**7.5 min sheets:** Bodega Head, CA  
**Approx. Lat.:** 38° 20' 0" N  
**Approx. Long.:** 123° 01' 40" W  
**Permitting Info:** Mrs. Knight 702-731-4715 or 702-794-0049, Butch Noonan, 707-882-2715  
**Access:** 4WD vehicle. 2WD vehicle can get within 200 m in dry.  
**Security:** May be left unguarded.  
**Location:** On a ridge above Bodega Bay.

**To Reach:** To reach from the intersection of State Highway 1 and Bay Flats road in Bodega Bay, go south on Highway 1 for 1.0 miles to two driveways on the left, opposite an unpaved pullout on the right. The northern driveway is well-developed and paved, and leads to several houses and a new fire station under construction as of 4/97. The southern driveway is located about 20 meters south of the northern one, is partially hidden by trees and has a locked gate. As of April 1997, the combination on the lock with the short shank was 2426. Pass through the gate and proceed 0.8 miles on the road to a reverse fork left and an abandoned house ahead. The mark is about 200 meters up the hill to the left, to the north-northeast. In a 4WD vehicle, take the reverse fork left uphill, then bear right and continue up the slope to the mark. The mark is located at the high point of a flattened area on the ridge, and was marked by a small cairn of rocks in April 1997. The original description mentions an old fenceline and a witness post, but no sign of either were found.

The property is currently owned by a Mrs. Knight of Nevada (702-731-4715 or 702-794-0049). Her nephew Butch Noonan (707-882-2715) is a more local contact; he lives in Manchester, about two hours drive to the north. As of April 1997, a sign indicated that the property was for sale by owner.