

LAGUNITAS CREEK COHO SALMON SPAWNER SURVEY REPORT 1999-2000

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LIST OF ACRONYMS

California Department of Fish and Game	CDFG
California Department of Parks and Recreation	State Parks
cubic feet per second	cfs
Ecologically Significant Unit	ESU
Endangered Species Act	ESA
Marin Municipal Water District	MMWD
National Marine Fisheries Service	NMFS
National Park Service	NPS
Samuel P. Taylor State Park	S.P. Taylor
State Water Resources Control Board	SWRCB
United States Geological Survey	USGS

EXECUTIVE SUMMARY

The Marin Municipal Water District (MMWD) conducted coho salmon (*Oncorhynchus kisutch*) spawner surveys on Lagunitas Creek between 2-November-1999 and 2-February-2000. Surveys were conducted weekly on Lagunitas Creek between Tocaloma Bridge and Peters Dam. We also conducted surveys on San Geronimo Creek starting on 22-November-1999. National Park Service staff conducted surveys in Devil's Gulch starting on 12-January-2000 and also in Olema Creek. We terminated spawner surveys after 2-February-2000 when the coho spawning run appeared to have ended and steelhead observations began to outnumber coho observations.

We observed the first coho in Lagunitas Creek on 3-November. The majority of live coho and redd construction in the Lagunitas Creek drainage occurred in the month of January. During the surveys, we observed a total of 203 redds and 568 live coho. We observed 139 of these redds and 371 of the coho in Lagunitas Creek, 58 redds and 176 coho in San Geronimo Creek, and three redds and 11 coho in Devil's Gulch. The remaining three redds and 10 coho were observed by volunteers in Arroyo Road Creek (a small tributary to San Geronimo Creek). No coho or redds were observed in Larsen Creek. We also took fin and muscle samples from 45 of 55 carcasses found in Lagunitas and San Geronimo Creeks. These samples were sent to Bodega Marine Laboratory for genetic analysis.

This year's spawning run was stronger than last year's run but not as strong as the 1996/'97 and 1997/'98 runs. Last year we observed 184 redds and 123 coho. In 1996/'97 and 1997/'98 we observed 254 and 253 redds, respectively. Most of the fish that spawned this year were descendants of fish that spawned in 1996/'97. This year class has been the strongest of the three coho year classes observed since juvenile salmonid surveys were started in 1993.

Under the minimum stream flow requirements mandated by the California State Water Resources Control Board (SWRCB) order WR95-17, MMWD ensured upstream migration flows of 35 cubic feet per second (cfs) for three-day periods. Releases from Kent Lake were conducted for these upstream migration flows starting on 20-November, 30-November and 4-January. This year's upstream migration flows were more than sufficient to allow fish passage and appeared to be somewhat effective at encouraging coho to swim upstream.

Improvements made to Roy's Dam (on San Geronimo Creek) in 1999 to improve fish passage were highly successful. We observed 34 live coho and 20 redds upstream of the dam and the percentage of San Geronimo Creek coho spawning above the dam was the highest recorded to date.

1.0 INTRODUCTION

1.1 Background

Lagunitas Creek originates on the north slope of Mount Tamalpais and flows in a northwesterly direction for 25 miles where it discharges into Tomales Bay (Figure 1). San Geronimo Creek, Devil's Gulch, Nicasio Creek, and Olema Creek are the major tributaries to Lagunitas Creek. Devil's Gulch, which flows through National Park and State Park land before entering Lagunitas Creek, is the smallest of these tributaries but it usually has perennial surface flows in addition to good habitat characteristics, which make it an important coho stream. Other tributaries to Lagunitas Creek that are known to support coho include Cheda and McIsaac Creeks. Woodacre, Larsen and Arroyo Road Creeks are tributaries to San Geronimo Creek that provide coho spawning habitat. Fifty two percent of the land within the Lagunitas Creek watershed is publicly owned by either the Marin Municipal Water District (MMWD), the National Park Service (NPS), California Department of Parks and Recreation (State Parks), or Marin County Open Space District (MCOSED).

MMWD is a public agency that diverts water from the Lagunitas Creek drainage in Marin County, California to provide water to residents of central and southern Marin. MMWD operates four reservoirs on Lagunitas Creek, including Lake Lagunitas, Bon Tempe Lake, Alpine Lake and Kent Lake. In addition, Nicasio Reservoir stores water on Nicasio Creek. MMWD diversions are permitted and regulated by the California State Water Resources Control Board (SWRCB). The MMWD reservoirs have altered flows in Lagunitas Creek by reducing peak winter storm flows and, with releases from Kent Lake, increasing summer low flows (SWRCB 1995). Natural runoff patterns in Lagunitas Creek were characterized by high, flashy winter storm flows and low summer flows, with substantial year to year variation in total runoff. In its 1995 Order WR95-17, the SWRCB required MMWD to provide releases from Kent Lake to ensure minimum stream flows at the U.S. Geological Survey (USGS) stream gage in Samuel P. Taylor State Park for the benefit of the aquatic resources in Lagunitas Creek. The normal year flow requirements on Lagunitas Creek are outlined in Table 1. In addition to requiring minimum stream flows, the SWRCB Order also called for four upstream migration flows. An upstream migration flow is a continuous flow of at least 35 cfs for three days as measured at the USGS gage in the State Park. Upstream migration flows are required on 15-November, 1-December, 1-January, and 1-February in the absence of a natural storm event in the month preceding those target dates.

The SWRCB also ordered MMWD to develop and implement a fisheries monitoring plan as well as a sediment and riparian management plan for the Lagunitas Creek watershed (SWRCB 1995). In 1996, MMWD prepared the *Aquatic Resources Monitoring Workplan for the Lagunitas Creek Drainage, Marin County, California: Final Report* (MMWD 1996). In 1997, MMWD prepared the *Lagunitas Creek Sediment and Riparian Management Plan: Final* (MMWD 1997). Both plans have been approved by the SWRCB.

Table 1. Normal water year minimum flow requirements on Lagunitas Creek at S.P. Taylor State Park.

Time Period		Flow (cfs)
1/15-November*	- 31-December	20
1-January	- 15-March	25
15-March	- 31-March	20
1-April	- 30-April	16
1-May	- 15-June	12
16-June	- 1/27-November*	8

* The minimum flow of 20 cfs in November is to begin following the first storm that produces a “trigger” flow of 25 cfs at the USGS gage at S.P. Taylor State Park. In the absence of a storm causing a “trigger” flow, the 20 cfs requirement will become effective on 15-November of each year. In 1999, the SWRCB granted a request to delay the November flow increase until 27-November or following the first “trigger” flow.

One element of MMWD’s aquatic resource monitoring program is to conduct annual coho spawner surveys on the Lagunitas Creek system. MMWD sponsored coho spawner surveys on Lagunitas Creek, Devil’s Gulch, and San Geronimo Creek during the 1982/’83 and 1983/’84 spawning seasons and annually since the 1995/’96 season. During the years between 1984 and 1995, one-day to a few day spawner surveys were conducted by the California Department of Fish and Game (CDFG), and by ENTRIX in 1992, which gave a snapshot look at the spawning season.

The objectives of the spawner surveys are to determine the distribution and range of spawning and the relative spawner abundance within the watershed. This information will track the annual spawning run in Lagunitas Creek. It will also help satisfy one of the goals of the aquatic resource monitoring plan, which is to determine if MMWD management activities (water releases, sediment control, and riparian restoration) are improving habitat utilization and, ultimately, the abundance of coho salmon returning to the Lagunitas Creek watershed.

1.2 Coho Salmon Life History and Status

Coho salmon are anadromous fishes, spending their adult life in the ocean, migrating into freshwater streams to spawn, rearing at least partially in freshwater, and migrating to the ocean as smolts. Most coho salmon from California streams spend approximately 18 months in freshwater (including incubation) and 18 months in the ocean, returning to spawn in their natal stream in their third year, after which they die (Shapalov and Taft 1954). Unlike other salmonids in California, this three year cycle is fairly rigid and spawning years with relatively poor reproductive success can result in poor spawning runs three years later (D.W. Kelley & Associates and ENTRIX 1992). Coho can also be grouped in year classes of three-year increments. For example, 1994 and 1997 young-of-the-year coho are from the same year class, with the 1997 fish being the progeny of spawners in the 1994 year class. Adult coho begin to arrive near the mouth of Lagunitas Creek in late summer and fall to begin acclimation to freshwater before migrating upstream (Bratovich and Kelley 1988). The spawning period is generally from mid-November to mid-January but adult coho have been observed as early as mid-October and as late as early February.

Coho salmon usually spawn at the heads of riffles with gravel substrate (Moyle 1976). Females may excavate small test pits (or “diggings”) in the gravel substrate before deciding on a site to lay her eggs. Once decided, she will dig a larger pit (called a “redd”) where she deposits her eggs. Often more than one male will fertilize the eggs before the female covers the eggs with additional gravels (Moyle 1976). Following spawning, the female may guard the redd for up to two weeks before dying (Groot and Margolis 1991). Juvenile coho emerge from the gravel the following spring and usually rear in the stream for one year before migrating to the ocean (Moyle 1976). The majority of coho return as three year old fish, however, “jacks” return as sexually mature, two year old males (Groot and Margolis 1991).

Coho salmon in the Central California Coast Evolutionarily Significant Unit (which includes the Lagunitas Creek watershed) have been listed as “threatened” under the federal Endangered Species Act (61 FR 56138). Likewise, the present population in Lagunitas Creek has been significantly reduced from historical levels (Brown et al 1995). Recent surveys, however, may indicate an upward trend in the coho salmon population. Spawner surveys from the mid-1980’s indicated that approximately 100 coho spawned annually in Lagunitas Creek and its tributaries (D.W. Kelley & Associates and ENTRIX 1992). In the last five spawning seasons we have observed an average of over 400 spawning coho and 200 redds.

2.0 METHODS AND SURVEY AREA

Stream sections were walked every week by a two-person crew. Surveys were conducted by Eric Ettlinger, Gregory Andrew, Jon Goin and Bill Irons. Helena Drumm, Josh Knox and Michael Meinz also provided assistance. Each stream section was surveyed from the downstream end to the upstream end. We divided Lagunitas Creek into three sections: 1) Tocaloma Bridge to Devil’s Gulch (approximately 2.5 miles), 2) Devil’s Gulch to Shafter Bridge (approximately 3.0 miles) and 3) Shafter Bridge to Peters Dam (approximately 0.5 miles). We generally walked sections two and three on the same day. San Geronimo Creek was walked from its mouth to the confluence of Woodacre Creek, approximately 4.5 miles upstream. Staff of the Salmon Protection and Watershed Network (SPAWN) surveyed two small tributaries to San Geronimo Creek, Larsen and Arroyo Road Creeks. Roy’s Dam is a significant landmark three miles upstream of the mouth of San Geronimo Creek where fish must swim through a fish ladder or jump over four small, artificial waterfalls to migrate upstream of the dam. These waterfalls were built during the summer of 1999 and this spawning run was the first test of their effectiveness at allowing fish to pass upstream. National Park Service staff surveyed Devil’s Gulch from its mouth to a fork at 1.3 miles upstream. The section of Lagunitas Creek from its mouth to Tocaloma Bridge was not surveyed because little spawning habitat exists in this section, deep pools and overhanging vegetation made it difficult to observe fish and because this section has not been systematically surveyed in previous years.

During the surveys we recorded observations of redds, live adult coho, coho carcasses, diggings and adult steelhead. Live fish were recorded as male or female or jack, their condition noted (color, wear marks, hooked jaw, etc) and their location in relation to landmarks such as tributaries or bridges was noted. All observed spawning activity was also recorded. We recorded the sex and length of recovered

carcasses and collected tissue samples so that genetic analyses could be performed by Bodega Bay Marine Lab. We attempted to determine if these coho carcasses had spawned by inspecting for retained eggs or milt. Other information recorded during each survey included: survey start and stop times, air and water temperature, weather conditions, and qualitative observations of stream flow, water clarity and visibility.

We assigned a number to each redd and marked its location in the field by hanging colored tape on adjacent vegetation. Redds were marked so no redd would be double counted during subsequent surveys and so any additional redds near that site could be distinguished. Each redd was flagged with red, striped flagging and yellow flagging. We labeled each flag with the date, the number of the redd, location of the redd with respect to the channel (i.e. mid-channel, left or right bank, etc), and the number of coho, if any, observed on the redd. If it was determined that a female made a small “test” pit and not a redd, the site was recorded as a “digging” and flagged with only yellow flagging. We also marked redd locations on a map of the creek for each survey date (Appendix A). We recorded the length and width of all redds. When fish were observed on a redd we approximated the redd dimensions. We attempted to identify when redds appeared to have been built on or overlapping older redds. High levels of such “superimposition” can reduce salmon breeding success.

The data on live coho and redds were compiled and compared to previous years. Rainfall and stream flow data were also compiled so we could analyze the numbers of coho relative to changes in stream flow.

We had no way of positively determining if we were recounting the same fish during subsequent surveys or missing fish during the intervals between surveys. We attempted to survey upstream stream sections before downstream sections to reduce the possibility of recounting the same fish moving upstream. For example, we surveyed San Geronimo Creek first, Devil’s Gulch to Peters Dam next, and then Tocaloma Bridge to Devil’s Gulch. Most surveys on each section were conducted between six and nine days apart. In addition, an attempt was made to identify the number of double-counted fish after the survey season had ended.

3.0 RESULTS

3.1 Live Coho Salmon, Redds, and Carcasses

We observed a total of 203 redds and 568 live coho during the spawner surveys in Lagunitas Creek, San Geronimo Creek (including tributaries), and Devil’s Gulch (Table 2). A total of 184 redds and 123 live fish were recorded last year. There was a 10% increase in redds located and a 362% increase in live coho observed from last year (Figure 2). We located 47 more redds in Lagunitas Creek and one additional redd in San Geronimo Creek. Devil’s Gulch saw a decline of 29 redds. The relative proportions of redds in each creek are shown in Figure 3.

The 1997/'98 spawning survey (two years ago) recorded 253 redds and 428 live coho. The 1996/'97 spawning run, which is part of the same year class as this year's run, produced 254 redds and 549 live coho. Two tributaries to San Geronimo Creek, Arroyo Road and Larsen Creeks, were surveyed last year for the first time.

The lower, middle, and upper sections of Lagunitas Creek are Tocaloma Bridge to Devil's Gulch, Devil's Gulch to Shafter Bridge, and Shafter Bridge to Peters Dam, respectively (Figure 1). We observed 45 redds in the lower section, 74 redds in the middle section, and 20 redds in the upper section (Table 2). We also observed 63 live coho in the lower section, 227 live coho in the middle section, and 81 live coho in the upper section. These observations do not include 126 coho observations that were most likely double counts (Table 2).

The section of San Geronimo Creek from its mouth to Roy's Dam had 38 redds and 142 live coho. The section above Roy's Dam to Woodacre Creek had 20 redds and 34 live coho (Table 2). Surveys in Devil's Gulch recorded three redds and 11 coho. Volunteers surveyed Arroyo Road and Larsen Creeks, tributaries to San Geronimo Creek. Arroyo Road Creek had three redds and 10 live coho. No redds or coho were observed in Larsen Creek. Surveys in Olema Creek recorded 27 redds (Table 3).

We identified 25 coho redds that were superimposed by subsequent redds (12% of all redds). Four of these redds were superimposed by steelhead redds. Twenty superimpositions occurred in Lagunitas Creek (14% of Lagunitas Creek redds) and five were in San Geronimo Creek (8% of San Geronimo Creek redds). No data on superimpositions were collected for Devil's Gulch.

We located a total of 56 coho carcasses in the Lagunitas Creek system with 37 carcasses in Lagunitas Creek, 18 carcasses in San Geronimo Creek, and one carcass in Devil's Gulch. Genetic tissue samples were collected from 14 coho carcasses in San Geronimo Creek and 31 coho carcasses in Lagunitas Creek. Of the 45 coho carcasses sampled, 22 were females, 15 were adult males, four were "jack" males (2 years old) and four were of unknown sex. On 28-January we found a chinook salmon carcass 0.5 miles downstream of Shafter Bridge. This salmon was female and, based on its extremely worn caudal fin and lack of many retained eggs, had apparently dug a redd and spawned. No male chinook were observed and we don't know whether this salmon spawned successfully. This is only the second chinook salmon observed in Lagunitas Creek in five years of coho spawner surveys.

3.2 Stream Flows, Water Releases and Correlated Spawning Activity

Stream flows at the Samuel P. Taylor gage were fairly constant at eight cfs from 1-July to 27-October-1999 when a fast moving storm dropped 1.5 inches of rain and raised stream flows to 11.6 cfs (Figure 4). The second storm of the season dropped 1.9 inches of rain between 6- and 9-November, raising stream flows to 13 cfs. For a week starting 14-November, a storm dropped a total of 2.5 inches of rain. MMWD took this opportunity to increase water releases to create an upstream migration flow of 35 cfs between 20- and 22-November. This flow was the first of the season to raise the stream flow in Lagunitas Creek above 25 cfs and triggered the SWRCB requirement to maintain a flow of 20 cfs through 31-December (hence this flow is also called a "trigger" flow). The second three-day upstream

migration flow was released coinciding with another small storm starting on 30-November. The month of December was unusually dry, with only 0.6 inches of rain falling between 1-December and 9-January-2000. The last upstream migration flow increased stream flows to 37 cfs between 4- and 6-January-2000 and flows remained above 25 cfs for the remainder of the spawner survey. Frequent storms from 10-January through the end of the spawner survey increased flows, reaching a maximum of 654 cfs on 24-January. These late storms were the first of the season to raise stream flows significantly above the minimum flows specified by the SWRCB order. The storms in January produced stream flows that exceeded the minimum SWRCB upstream migration flow requirement of 35 cfs for three days, so the upstream migration flow scheduled to begin on 1-February was not required.

We observed the first coho carcass and redd on 3-November-1999. The two November upstream migration flows and coinciding storms were followed by increasing numbers of live coho and redds (Figures 5 and 6). Redd observations began to decline after 8-December and remained low during the second half of December. Live coho and redd observations increased modestly following the third upstream migration flow in early January. The peak of the spawning season occurred on 13-January-2000 following the first significant rain in nearly six weeks. We observed 29 redds and 95 live coho that day, the highest number of coho observed in a single day since annual surveys started in 1995. San Geronimo Creek saw spawning activity peak on 21-January-2000, when we observed 26 redds and 79 live coho. Spawning activity declined sharply after 21-January and the number of coho carcasses increased. The last two presumed coho redds were observed on 28-January, following high flows earlier in the week. We observed eight redds after this date, but these were likely steelhead redds since steelhead were by that point more common than live coho.

4.0 DISCUSSION

We characterize this year's run as moderately strong relative to other runs during the last five years. More live coho were documented this year than ever before and the 203 redds observed was the third highest redd total since detailed annual surveys began in 1995 (Figure 2). The 1999/2000 coho spawner year class has been the strongest year class since 1993, based on juvenile and spawner surveys. The spawning run of 1996/'97 (which was the parent generation for most of the coho this year) was the strongest run in the last five years. Juvenile surveys in 1994 and 1997 (again the same year class) recorded the highest juvenile coho densities in seven years of such surveys.

The 139 redds built in Lagunitas Creek this year were far more than have ever been documented in this creek. Sixty-nine percent of the redds built this year were built in Lagunitas Creek (Figure 3). The high numbers of redds in Lagunitas Creek was in contrast to the unusually low numbers of redds in San Geronimo Creek and abysmal numbers in Devil's Gulch. The three redds and 11 live coho observed in Devil's Gulch was the poorest production ever documented for this drainage. The distribution of redds in these creeks can largely be explained by the timing of rainfall during the spawning season, which delayed access to Lagunitas Creek tributaries. Access by coho to Devil's Gulch was hampered by a gravel bar that did not wash out until storms finally arrived in mid-January. The first redd was observed in Devil's Gulch on 21-January-2000. Presumably, fish unable to enter Devil's Gulch before mid-

January built redds in Lagunitas Creek. The 60 redds observed in San Geronimo Creek were the fewest ever recorded, if one does not count the results of the 1995/'96 survey, when only six redds were observed but large parts of the creek were not surveyed. Fish had access to San Geronimo Creek this year throughout the spawning season, but observations of coho and redds were few until mid-January, indicating that access was at least hindered before then.

We observed more live coho and carcasses this year than have been documented to date. This high number is likely the result of performing more surveys (33 survey days this season compared with 19 last year) and having additional survey personnel (four surveyors throughout the season compared with one last year). The likelihood of double-counting live coho increases as one surveys more frequently, so we attempted to compensate for this double count at the end of the spawning season. One way we did this was to subtract 79 observations of coho in a deep pool ("Bike Bridge Pool") where between 17 and 31 coho were observed every week between 8-December and 7-January. These appeared to be the same coho each week and they left the pool when storms arrived in mid-January. Another way we compensated for double counts was to identify the redds where coho had been observed over multiple surveys. We assumed that these fish were holding over their redds during multiple surveys and only counted the first observation of each fish. This eliminated 47 additional coho observations, bringing the total down to 568 coho. It is nearly certain that we still counted some fish more than once, so this figure should be regarded as a very rough approximation of the number of coho present in the Lagunitas Creek drainage.

Superimposition of redds varied from slight overlap to complete reconstruction of the redd. High levels of intraspecific superimposition can indicate a shortage of adequate spawning habitat. Superimposition can kill eggs through physical shock, exposure, displacement into less favorable incubation conditions or predation (Groot and Margolis, 1991). The level of redd superimposition we observed (13%) does not include superimposition by steelhead after the coho spawner survey ended. The number of coho redds superimposed by steelhead is unknown but could be significant given that we observed four such superimpositions early in the steelhead run and coho and steelhead use the same habitats for redd construction. Superimposition of coho redds by other coho does not yet appear to be a significant problem, however.

The peak of this year's spawning run was the latest in the last five spawning seasons (Figure 7). The run was also unusual in that it occurred in two waves, with peaks separated by three weeks in December when we observed little spawning activity. When rain began to fall again in January, spawning activity quickly increased to its highest level of the season. These fish may have been waiting in Tomales Bay, in deeper creek sections downstream of Tocaloma Bridge or in deep pools throughout the creek. It seems likely given the quick response of these fish to increased flows that they were already in Lagunitas Creek, waiting to spawn when the rains finally arrived.

The first two upstream migration flows coincided with storm events, so the flows themselves may not be responsible for the subsequent increases in coho and redd observations. The third upstream migration flow, however, occurred near the end of a six-week dry spell and the subsequent increases in coho and redds can be confidently attributed to the increased flows. One day after the cessation of flows, 47

coho and nine new redds were observed. The full response to the flows could not be observed, however, because a large storm struck after only one survey had been conducted. Surveys after the storm recorded the highest numbers of coho and redds of the season. It is interesting to note that most of the coho holding in Bike Bridge Pool did not move out of the pool following the upstream migration flow, but were gone immediately following the storm. These fish may have been waiting for increased flows from San Geronimo Creek, instead of increased Lagunitas Creek flows.

The 1999/2000 coho spawning run was the first test of the improvements to Roy's Dam. During the summer of 1999, the crumbling apron of this 11-foot-tall dam was replaced with four stepped pools. The fish ladder next to the dam was left intact. Local residents reported observing coho jumping between pools and we observed coho holding in a pool on one occasion. Passage through the improved dam was very successful, with 20 redds and 34 live coho observed upstream of the dam. This accounts for roughly 34% of the redds in San Geronimo Creek, the highest percentage observed in the four years this data has been collected. Fish and redds were observed just downstream of Roy's Dam on 7-December but were not observed upstream of Roy's Dam until 12-January, possibly indicating that flows prior to this date were inadequate to allow passage upstream.

This year's coho spawning run will hopefully produce an abundance of juvenile coho. However, a major threat to the survival of the developing eggs and alevins is the scouring or burial of redds during high stream flows. Starting on 12-February-2000, a storm dropped 8.3 inches of rain over three days, raising the stream flow at Samuel P. Taylor State Park to 1,729 cfs. This flow may have been sufficient to scour or bury redds in the creek (Bratovich and Kelley, 1998). Since nearly two-thirds of redds this year were built below the confluence of San Geronimo Creek and were subjected to the highest flows, the potential for scouring of many redds is great. Survivorship of juvenile coho through the winter, spring and summer will be assessed during the 2000 juvenile salmonid survey. If survivorship during this period is high, chances are good that the 1999/2000 spawner year class will continue to be the strongest year class when it returns to Lagunitas Creek in 2002/2003.

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COHO SPAWNER SURVEY DATA

1999/2000 SURVEY RESULTS

Compiled by: Marin Municipal Water District

Updated 5/10/00

SURVEY DATE	LAGUNITAS			CREEK			SAN			GERONIMO			CREEK			TOTAL		
	Tocaloma-Devils Gulch	Devils Gulch-Shafter Bridge	Shafter Bridge-Peters Dam	Mouth-Roys Dam	Above Roys Dam	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	Live Coho	Carcasses	Redds	
2-Nov-98	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	0	0	0
3-Nov-98	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	0	1	1
9-Nov-98	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0
10-Nov-99	-	-	-	0	0	1	0	0	0	-	-	-	-	-	-	0	0	1
16-Nov-99	4	0	1	-	-	-	-	-	-	-	-	-	-	-	-	4	0	1
17-Nov-99	-	-	-	1	0	0	0	0	0	-	-	-	-	-	-	1	0	0
22-Nov-99	-	-	-	-	-	-	4	0	1	6	0	0	0	0	0	10	0	1
23-Nov-99	3	0	4	14	0	2	0	0	0	-	-	-	-	-	-	17	0	6
2-Dec-99	2	0	1	-	-	-	-	-	-	-	-	-	-	-	-	2	0	1
3-Dec-99	-	-	-	44	3	12	10	0	3	-	-	-	-	-	-	54	3	15
7-Dec-99	5	0	2	-	-	-	-	-	-	21	0	15	0	0	0	26	0	17
8-Dec-99	-	-	-	48	0	7	14	0	3	-	-	-	-	-	-	62	0	10
13-Dec-99	9	0	8	-	-	-	-	-	-	-	-	-	-	-	-	9	0	8
14-Dec-99	-	-	-	42	1	9	5	0	2	-	-	-	-	-	-	47	1	11
16-Dec-99	-	-	-	-	-	-	-	-	-	12	3	8	-	-	-	12	3	8
17-Dec-99	-	-	-	-	-	-	-	-	-	1	0	1	0	0	0	1	0	1
20-Dec-99	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
22-Dec-99	-	-	-	21	1	1	1	0	0	-	-	-	-	-	-	22	1	1
27-Dec-99	-	-	-	-	-	-	-	-	-	6	1	2	-	-	-	6	1	2
28-Dec-99	-	-	-	-	-	-	-	-	-	1	0	0	0	0	0	1	0	0
29-Dec-99	0	1	0	32	2	2	0	0	0	-	-	-	-	-	-	32	3	2
5-Jan-00	-	-	-	-	-	-	-	-	-	4	1	1	-	-	-	4	1	1
6-Jan-00	-	-	-	-	-	-	-	-	-	1	0	1	0	0	0	1	0	1
7-Jan-00	8	0	3	35	1	5	4	0	1	-	-	-	-	-	-	47	1	9
12-Jan-00	-	-	-	-	-	-	-	-	-	38	0	2	14	0	2	52	0	4
13-Jan-00	-	-	-	60	0	21	35	0	8	-	-	-	-	-	-	95	0	29
14-Jan-00	24	0	17	-	-	-	-	-	-	-	-	-	-	-	-	24	0	17
20-Jan-00	-	-	-	32	0	12	11	0	0	-	-	-	-	-	-	43	0	12
21-Jan-00	11	0	3	-	-	-	4	1	2	60	4	8	19	0	18	94	5	31
27-Jan-00	1	2	4	-	-	-	0	0	0	-	-	-	-	-	-	1	2	4
28-Jan-00	-	-	-	2	19	2	-	-	-	-	-	-	-	-	-	2	19	2
1-Feb-00	-	-	-	-	-	-	-	-	-	1	7	1*	1	2	1*	2	9	0
2-Feb-00	0	0	2*	0	4	4*	0	0	0	-	-	-	-	-	-	0	4	0
SUB-TOTAL	69	5	45	331	31	74	88	1	20	151	16	38	34	2	20	673	55	197
Corrected**	63			227			81			142			34			547	55	197
DEVIL'S GULCH SURVEYS^																11	1	3
SUB-TOTAL																558	56	200
LARSEN CREEK SURVEYS^^																0	0	0
ARROYO ROAD CREEK SURVEYS^^																10	0	3
TOTAL																568	56	203

Notes:

(-) Indicates that the spawner survey did not cover the area on that date.

* Indicates that redds observed were likely steelhead redds and are not included in the total count.

** Corrected coho observations compensate for coho that presumably were double-counted.

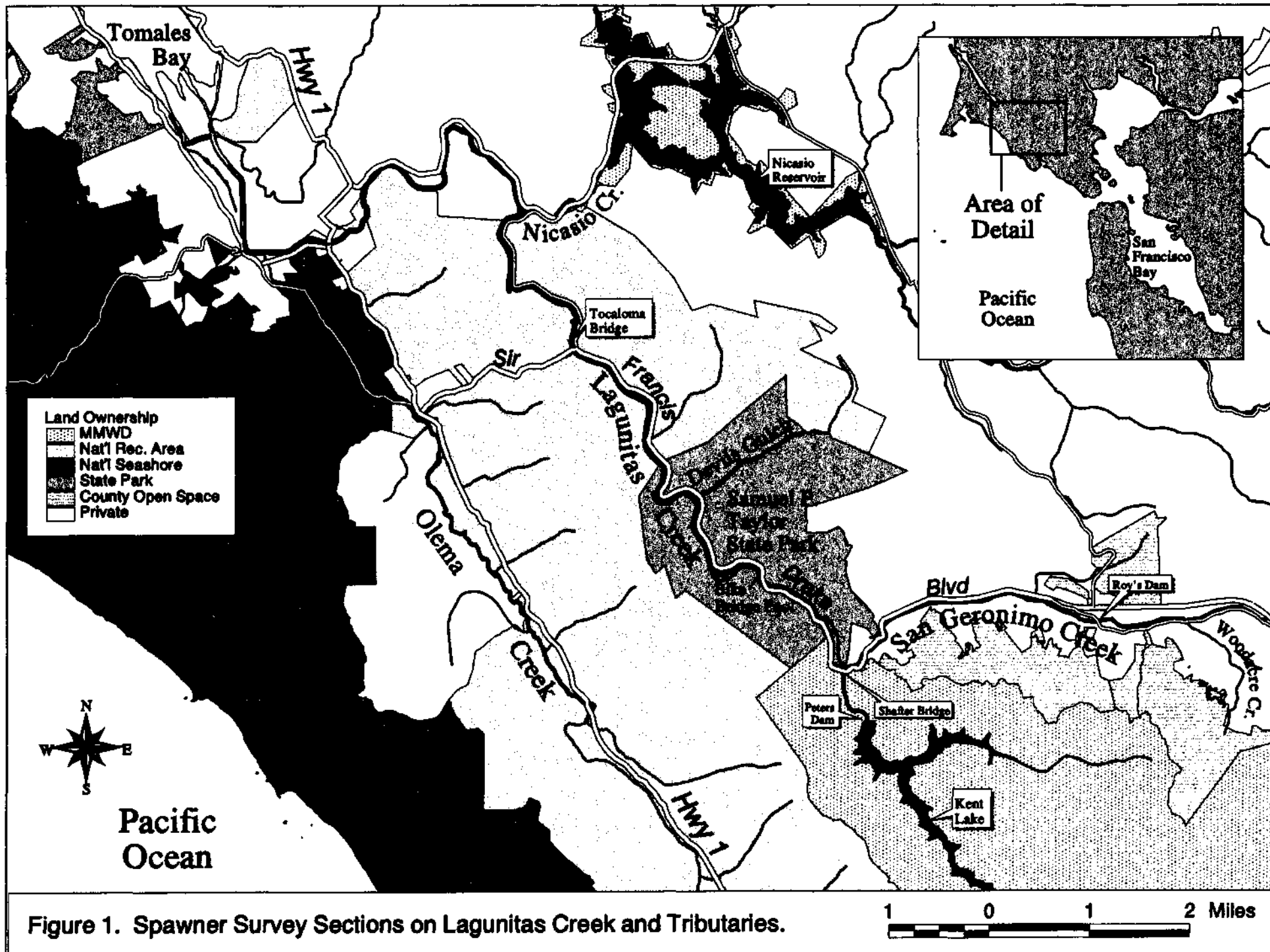
^ Devil's Gulch surveys were conducted by National Park Service staff.

^^ Larsen Creek and Arroyo Road Creek surveys were conducted by volunteers from the Salmon Protection and Watershed Network.

Table 2. Coho Spawner Survey Results, Spawning Season 1999-2000

	Lagunitas Creek	San Geronimo Creek	Devil's Gulch	Total	Olema Creek (for comparison)
1995-'96	70	6	10	86	n/a
1996-'97	98	115	41	254	n/a
1997-'98	80	121	52	253	126
1998-'99	92	60	32	184	42
1999-'00	139	61	3	203	27

Table 3. Coho Redds in the Lagunitas Creek Drainage, 1995/'96-1999/2000.



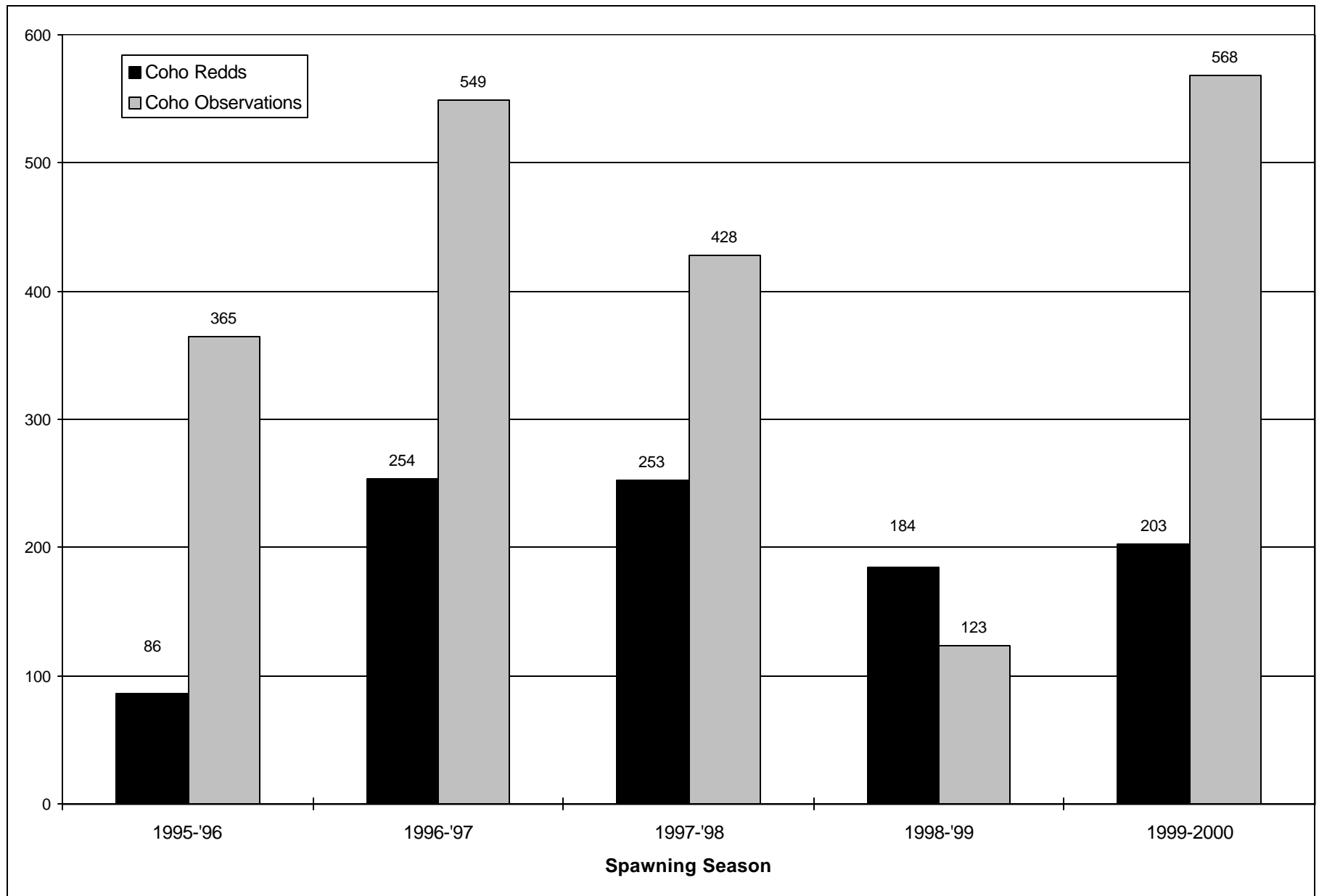
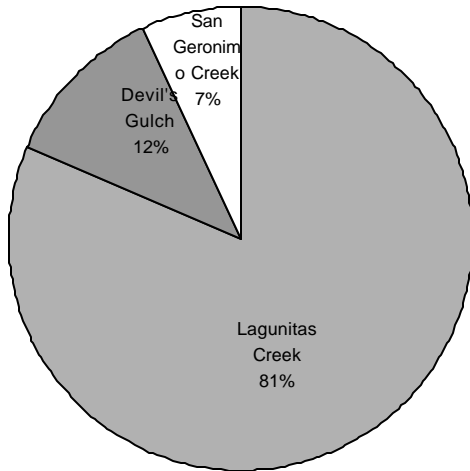
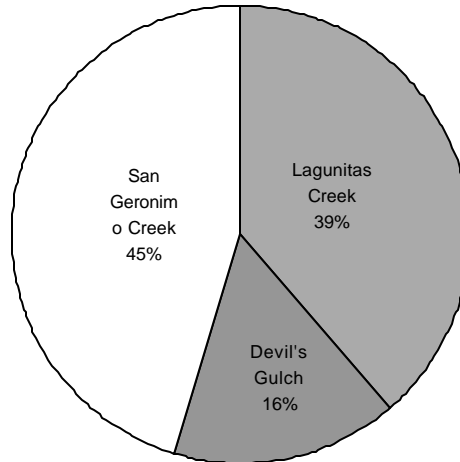


Figure 2. Coho Redds and Observations, Spawning Seasons 1995/'96-1999/2000.

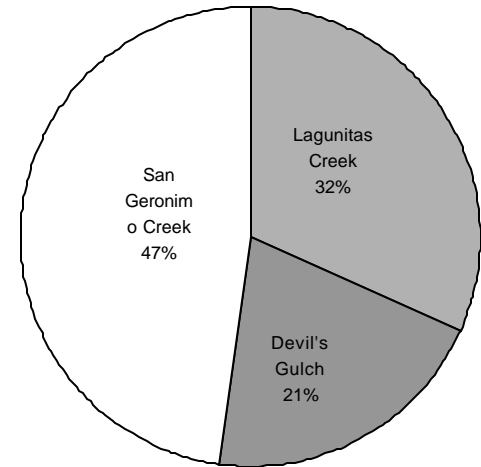
1995-1996



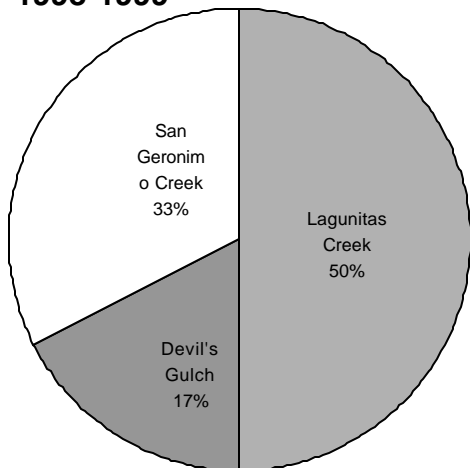
1996-1997



1997-1998



1998-1999



1999-2000

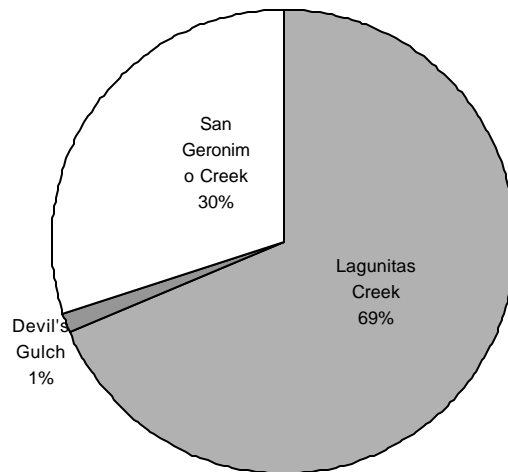


Figure 3. Coho Redd Locations in the Lagunitas Creek Watershed, Spawning Seasons 1995/96-1999/2000

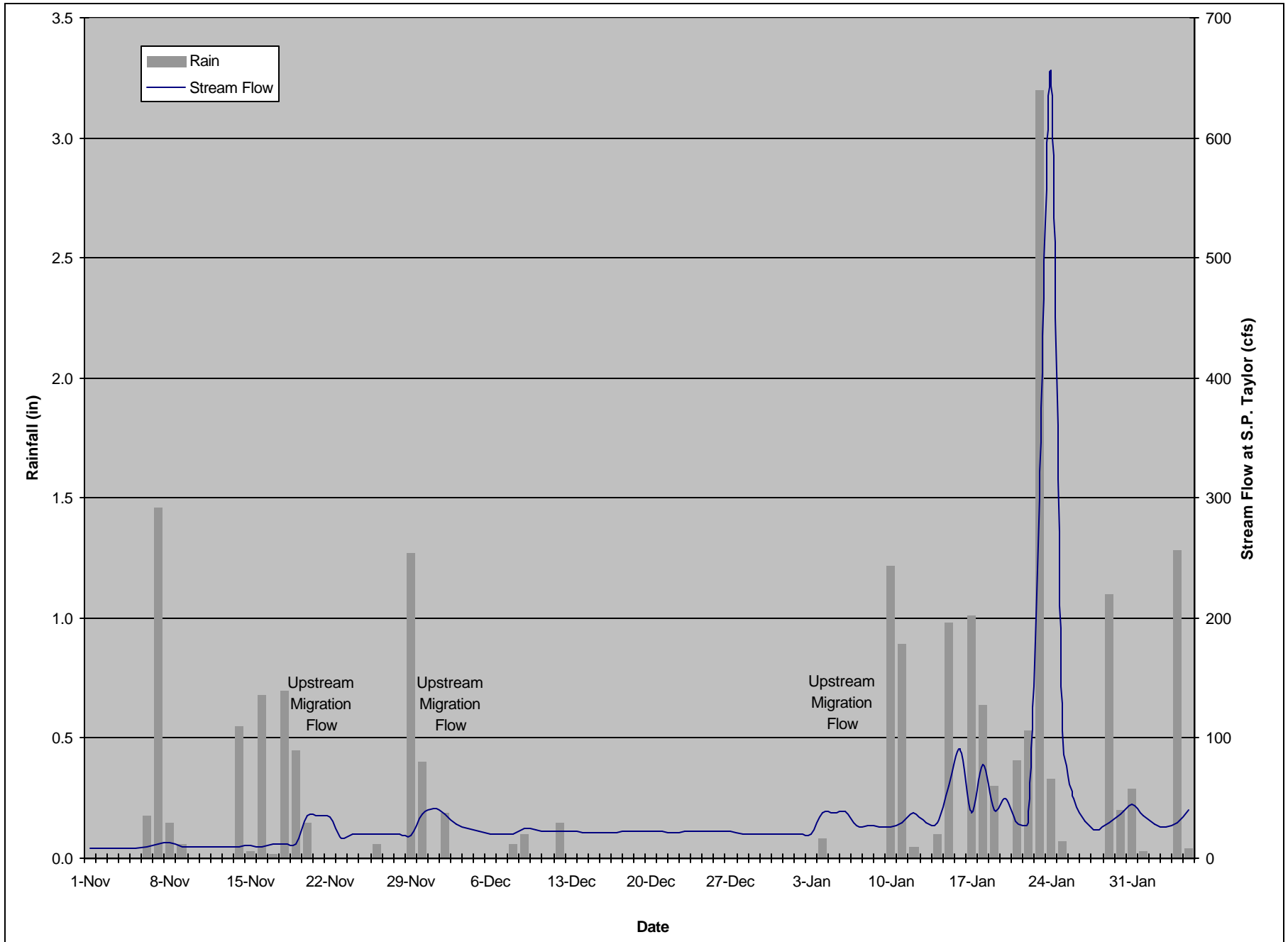


Figure 4. Rainfall and Lagunitas Creek Stream Flow, Spawning Season 1999-2000.

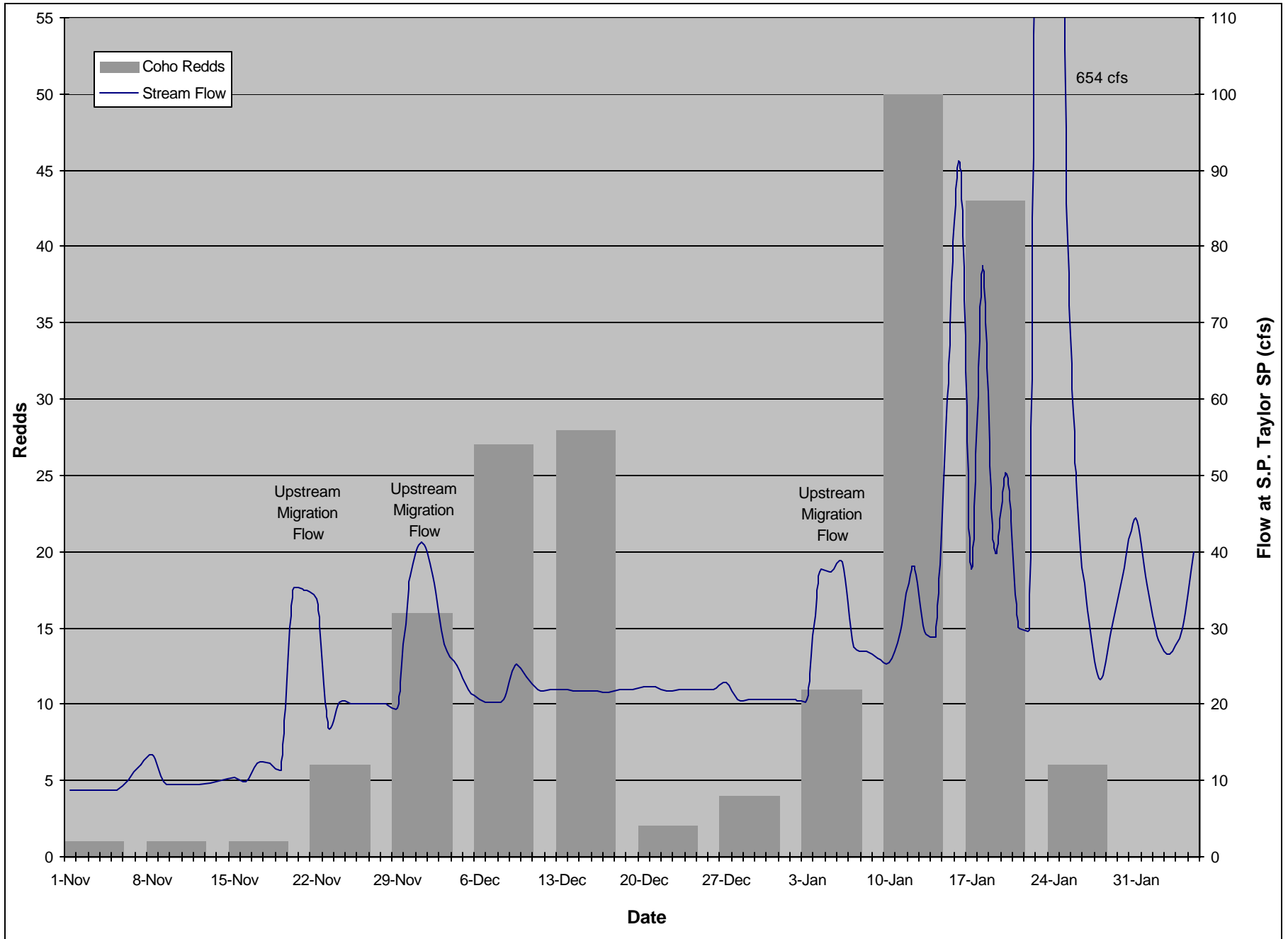


Figure 5. Coho Redd Observations, Spawning Season 1999-2000.

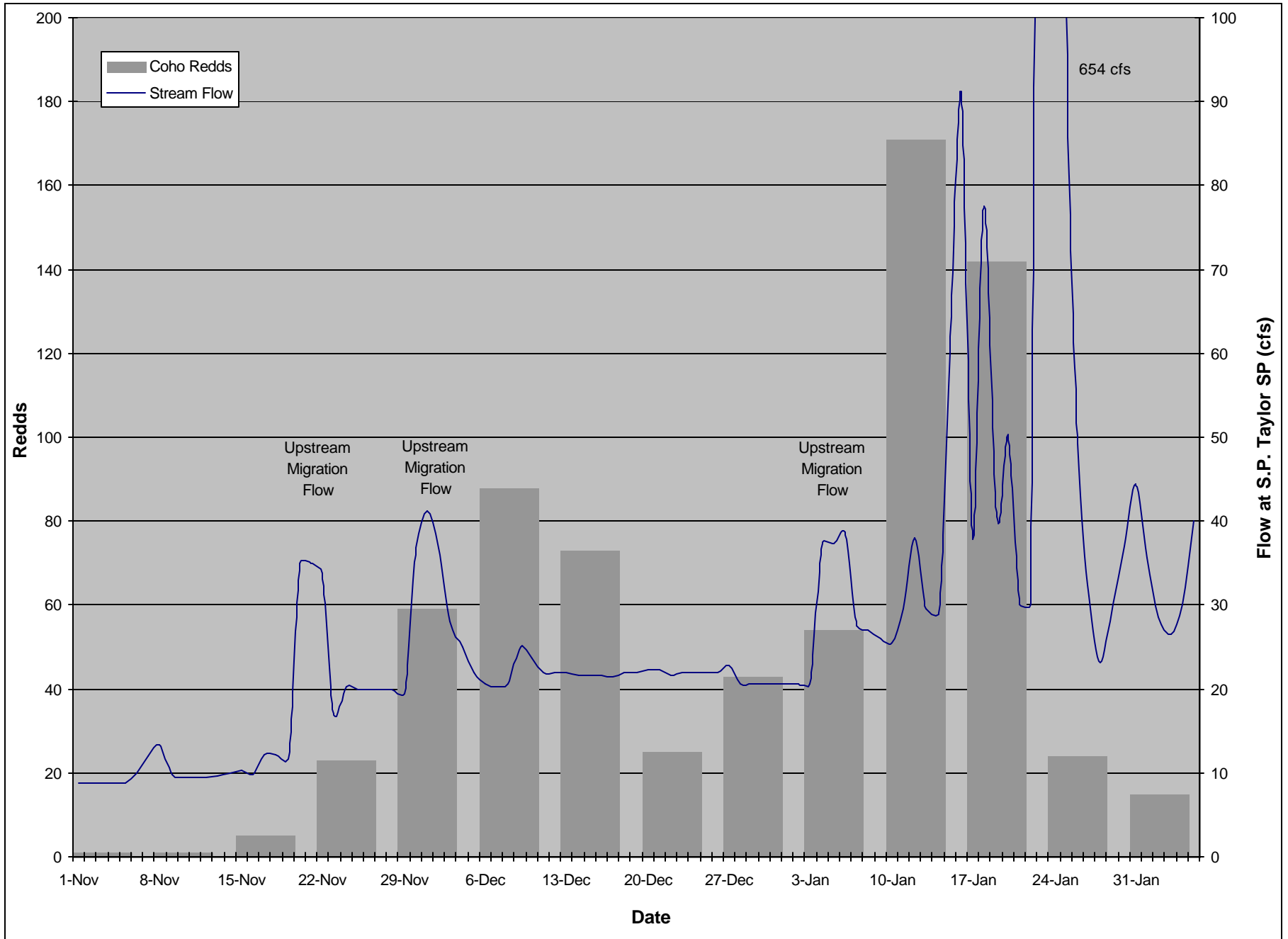


Figure 6. Live Coho Observations, Spawning Season 1999-2000.

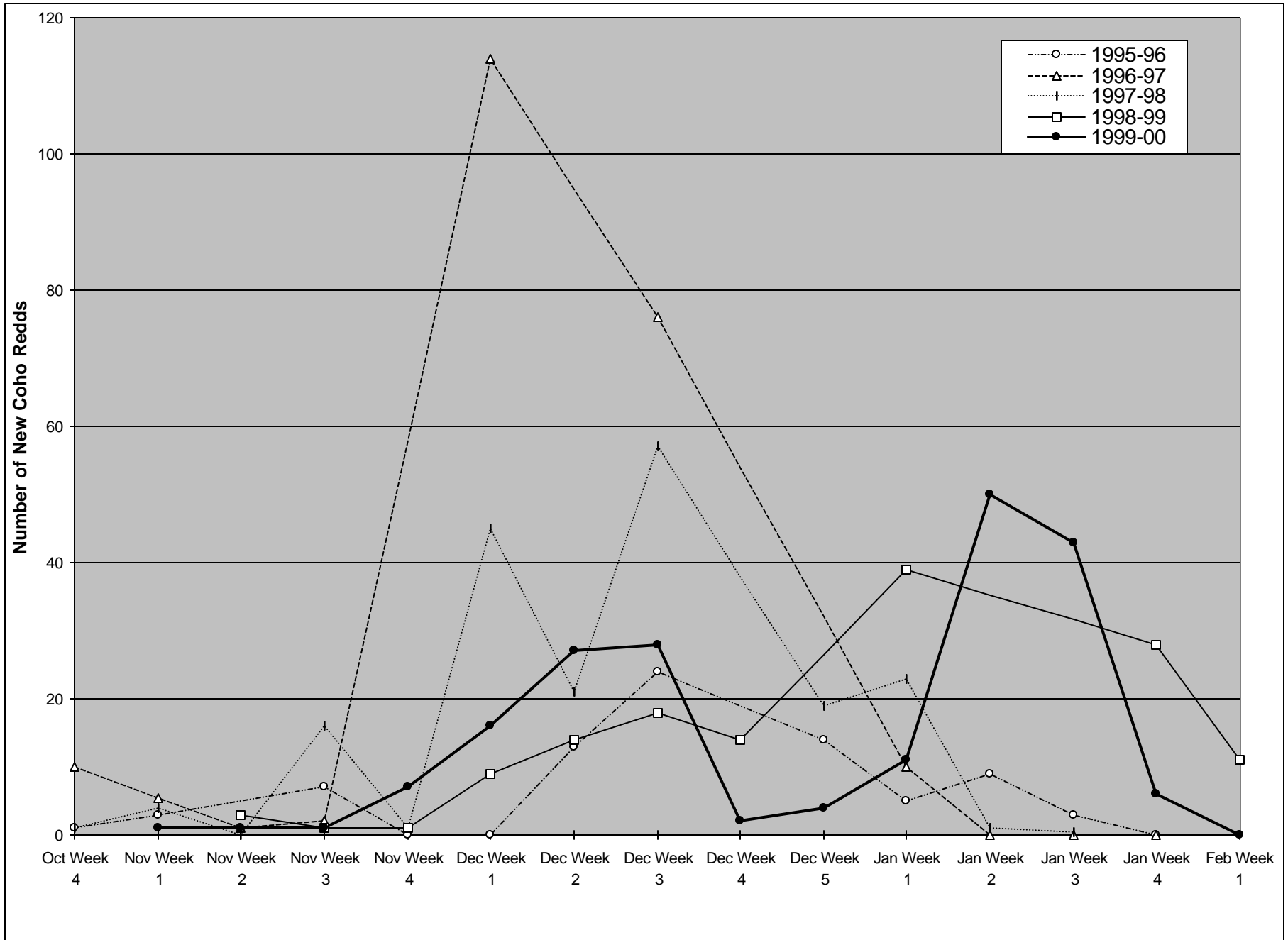
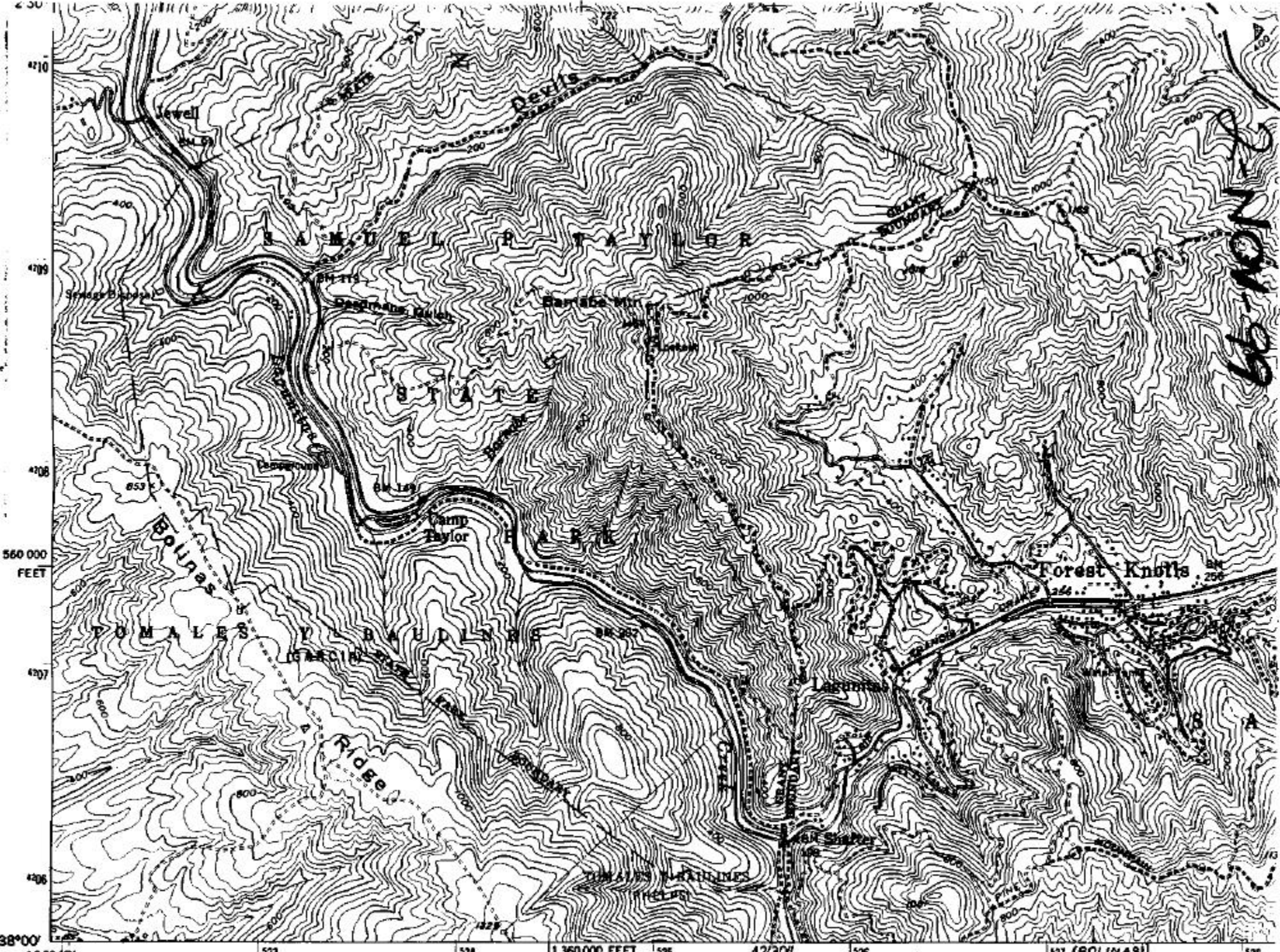


Figure 7. Timing of Coho Spawning Activity in Lagunitas and San Geronimo Creeks, Spawning Seasons 1995/96-1999/2000.

APPENDIX A

USGS 7.5 minute quadrangle topographic maps with redd locations on Lagunitas and San Geronimo Creeks.



66-101-28

38°00' 122°45' 523 1360000 FEET 525 42'30" 526 527 (BOLINAS) 1459 1 NW 528

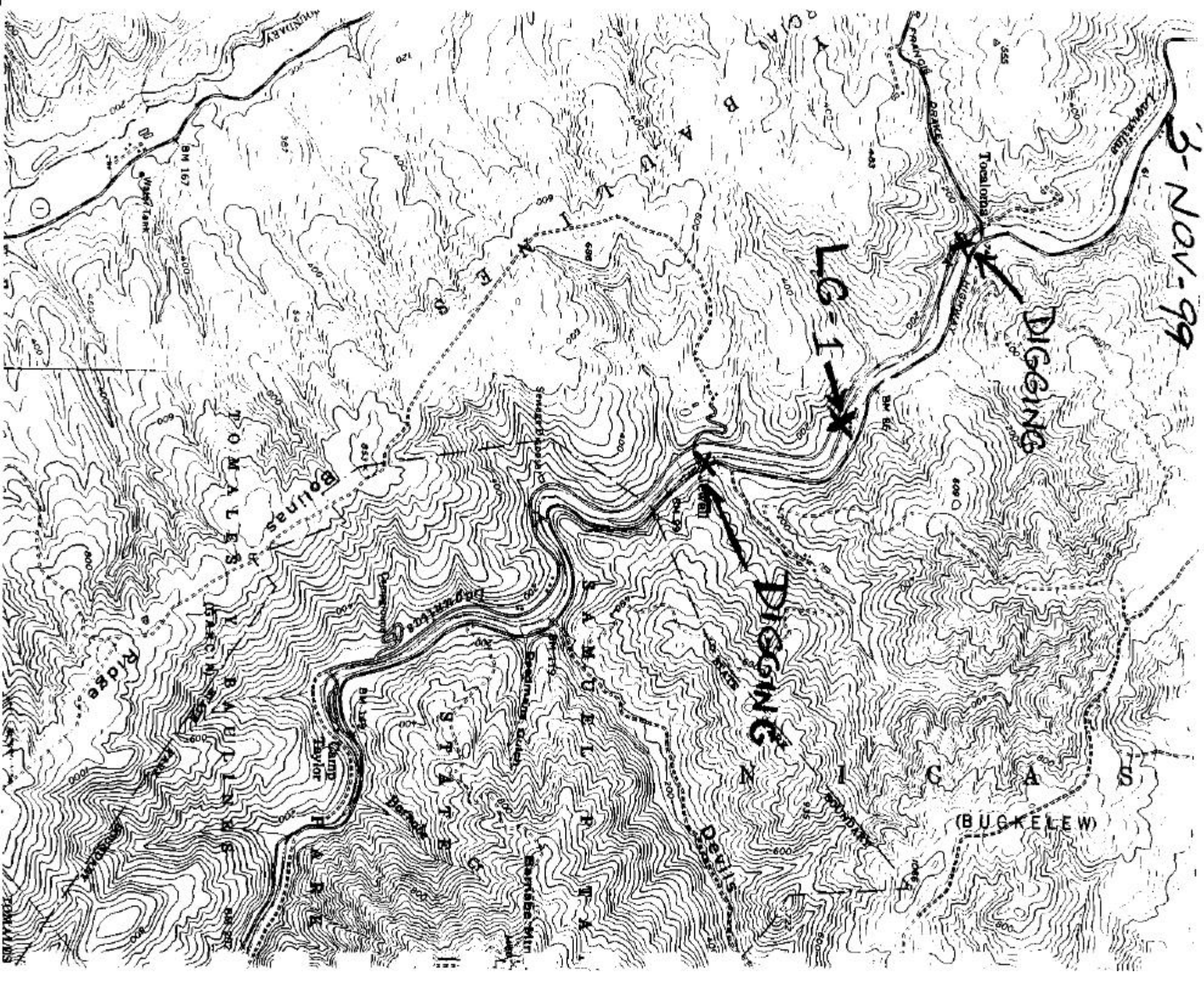
Mapped, edited, and published by the Geological Survey
Control by USGS, USC&GS, and USCE

2-NOV-99

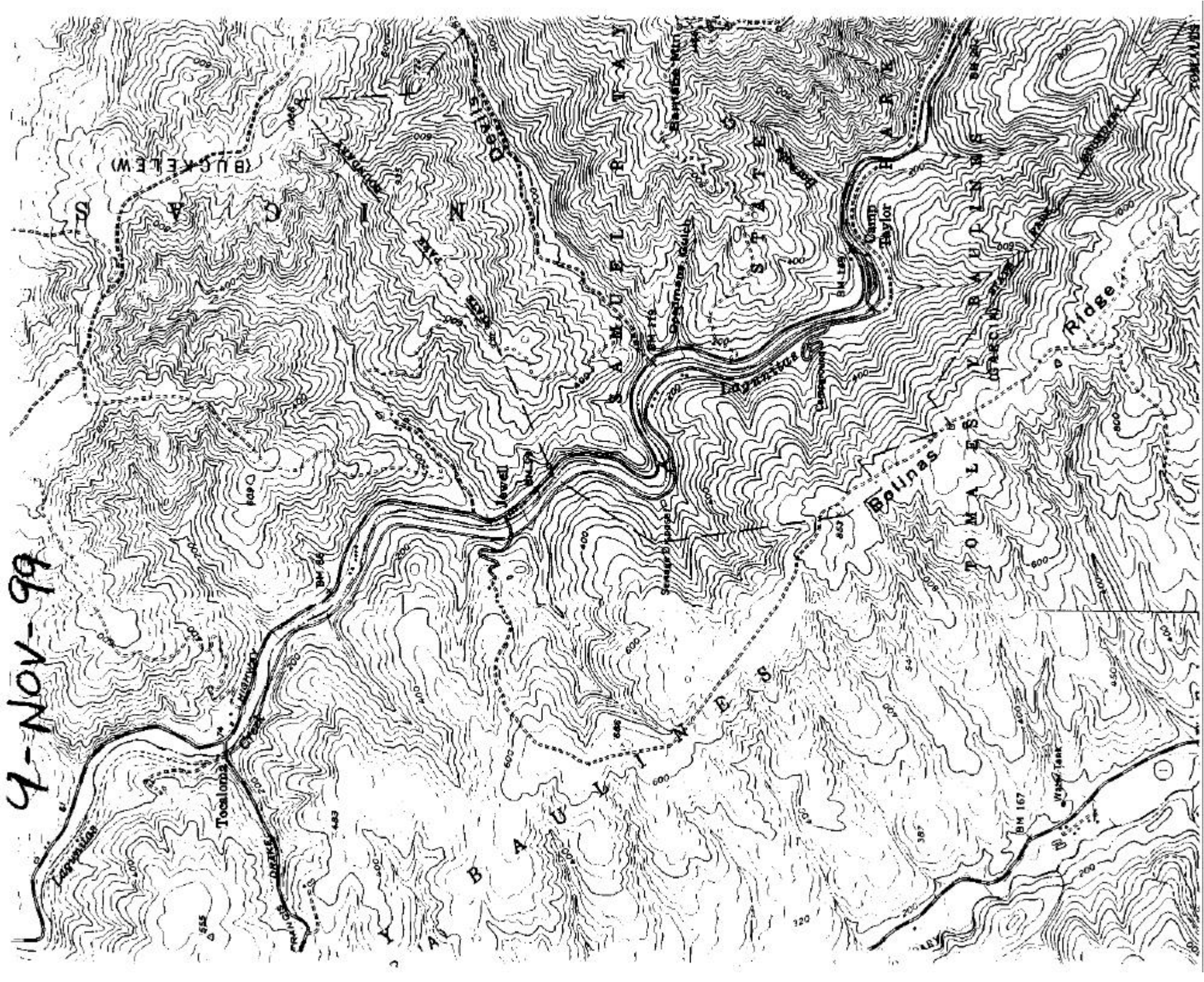
SCALE 1:24 000



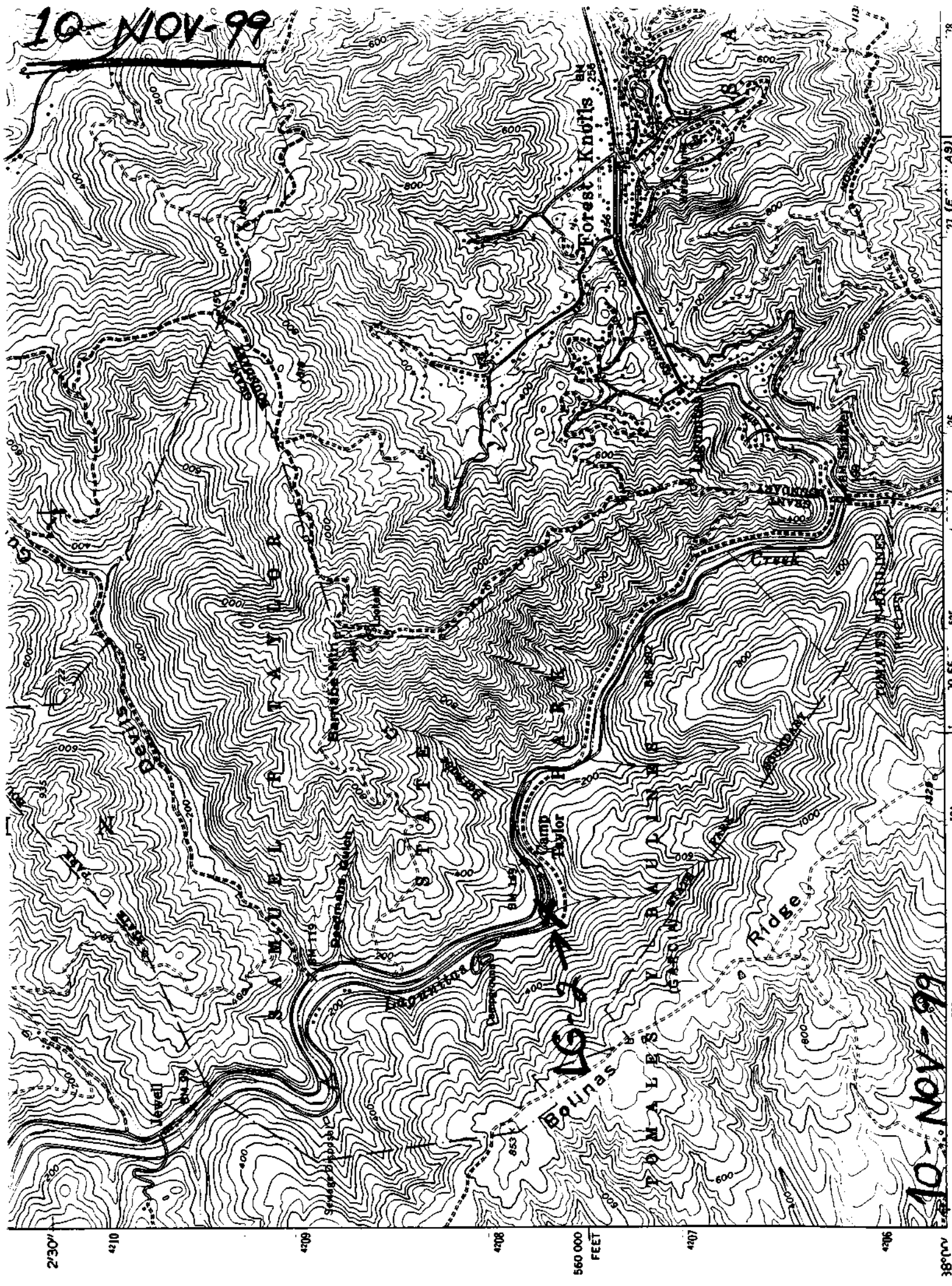
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9-NOV-99

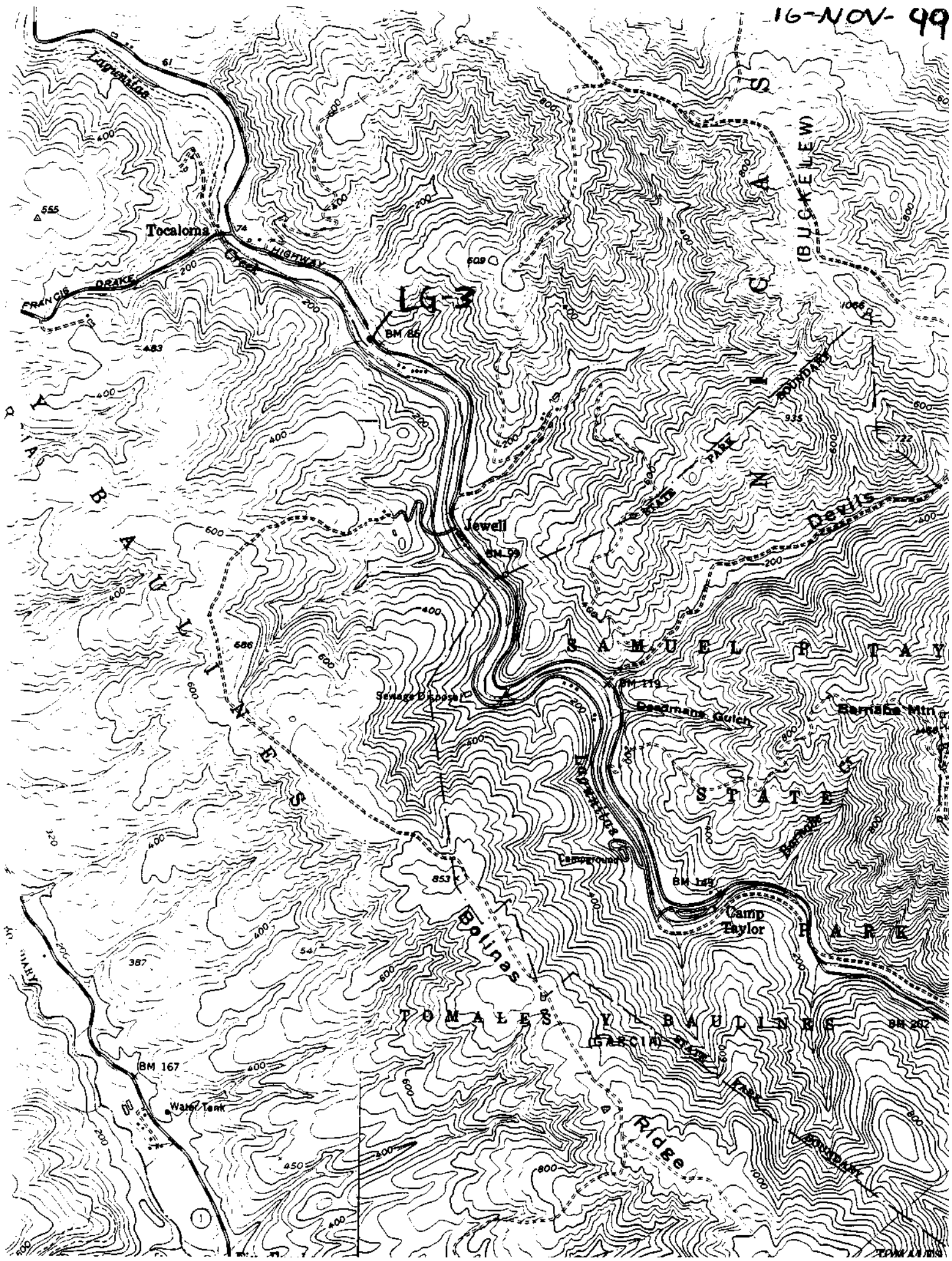


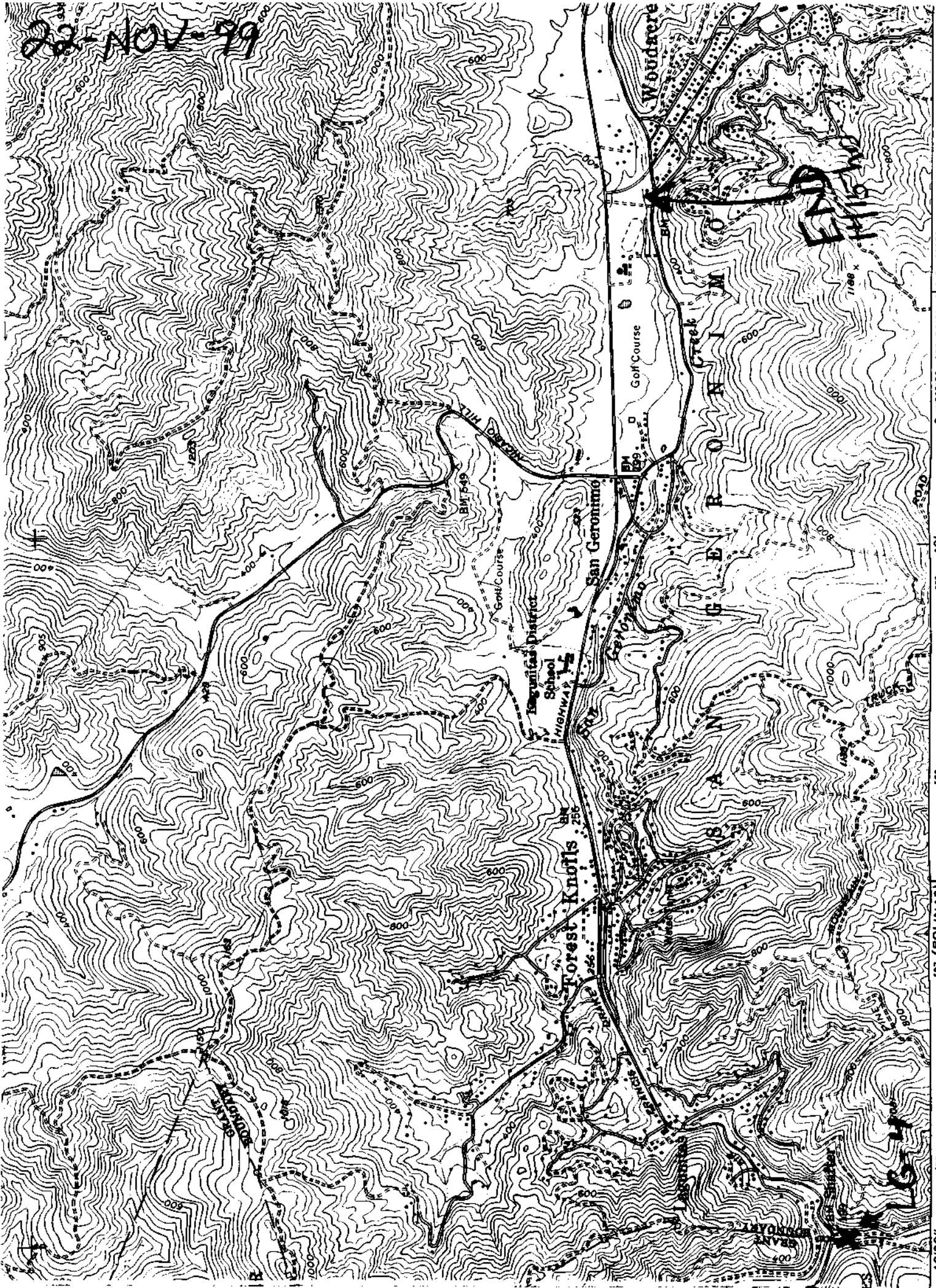
10-NOV-99



10-NOV-99

16-NOV-99





42°30' 26 28 30 32 34 36 38 40 42 44 46 48 50

37 (BOLINAS) 1459 1 NW SC1 24 (

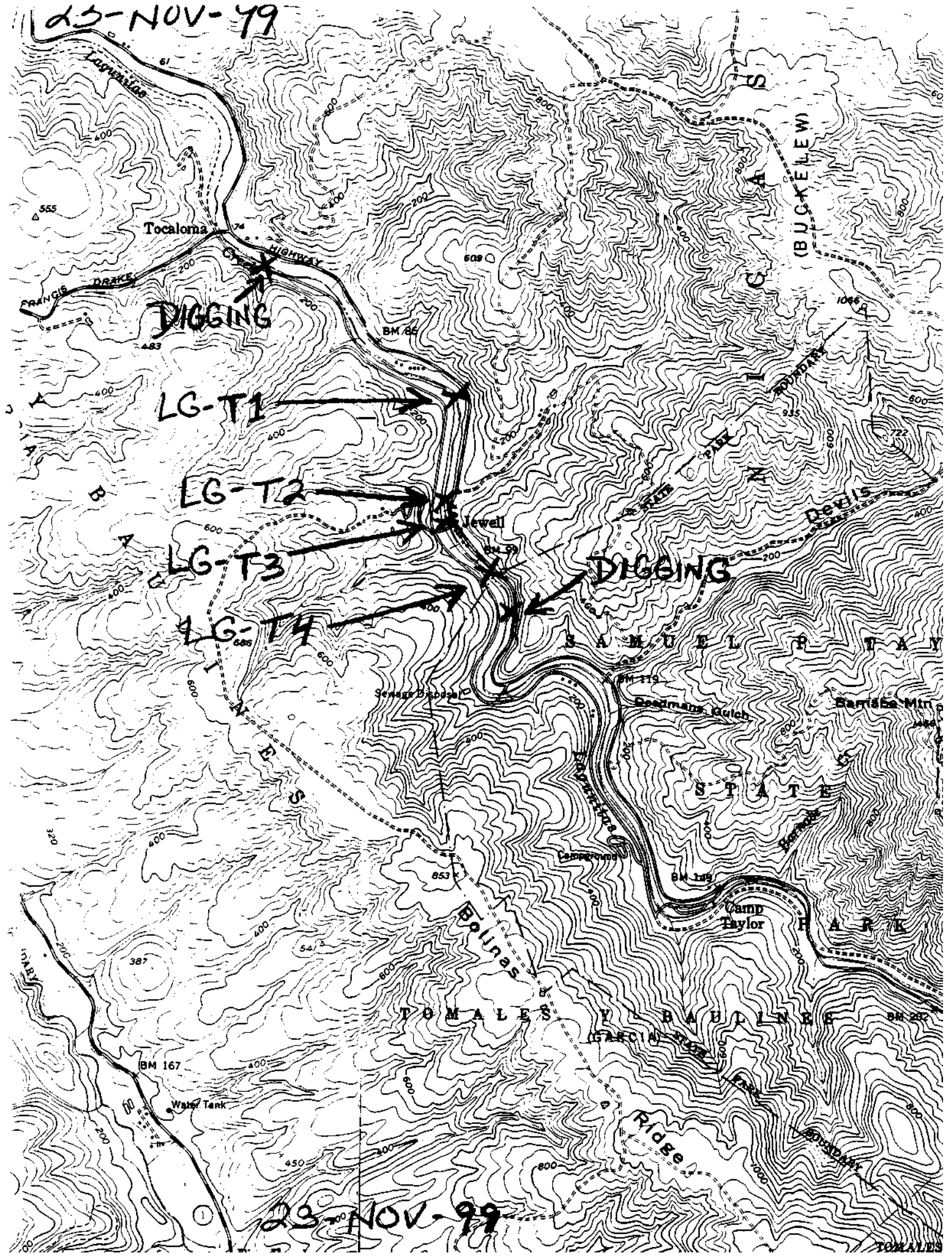
22 NOV 99

FBI

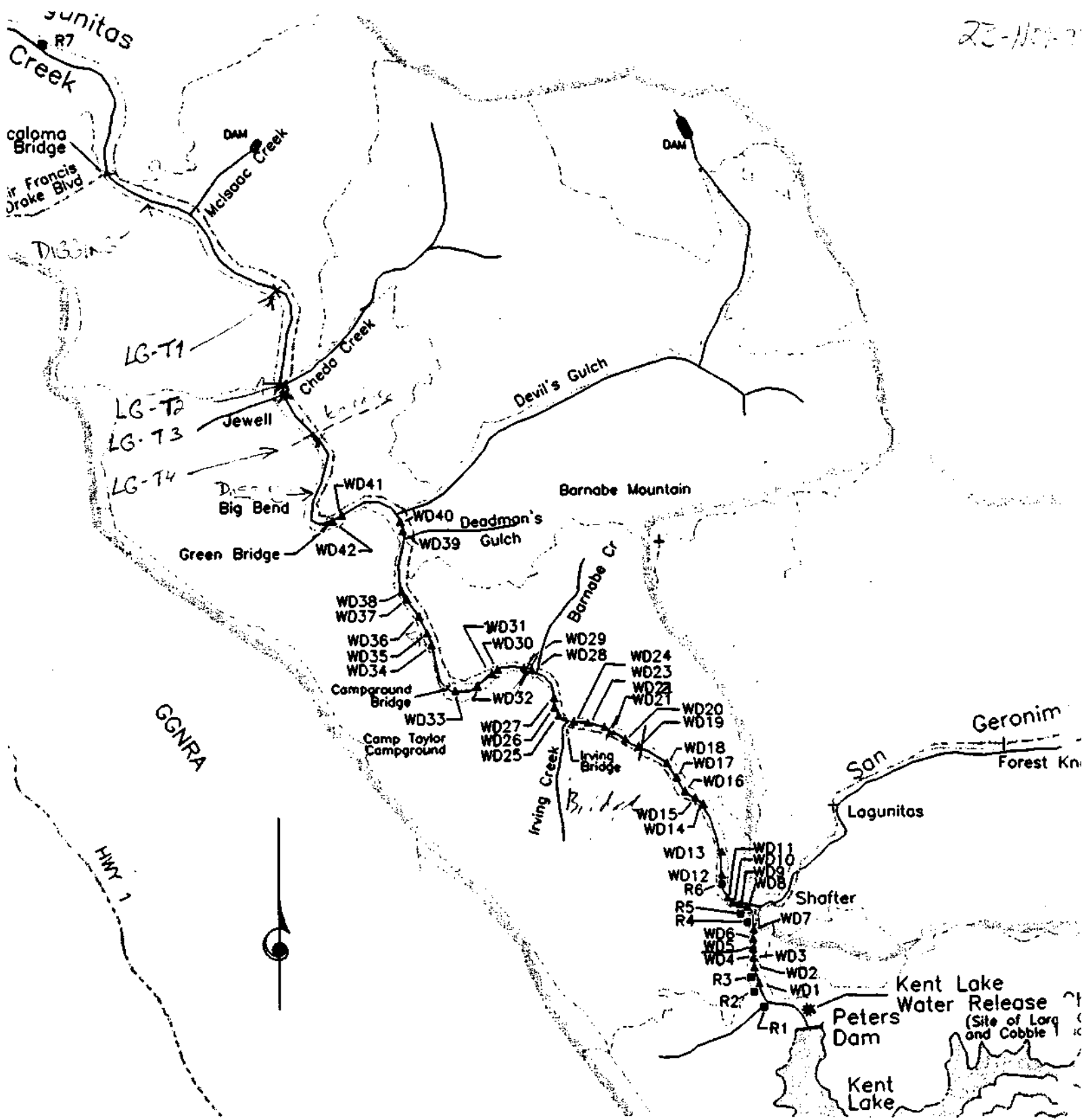
106 x 178

INTERIOR-GEOLOGICAL SURVEY, RESTON, VIRGINIA-1982

23-NOV-99



23-1107

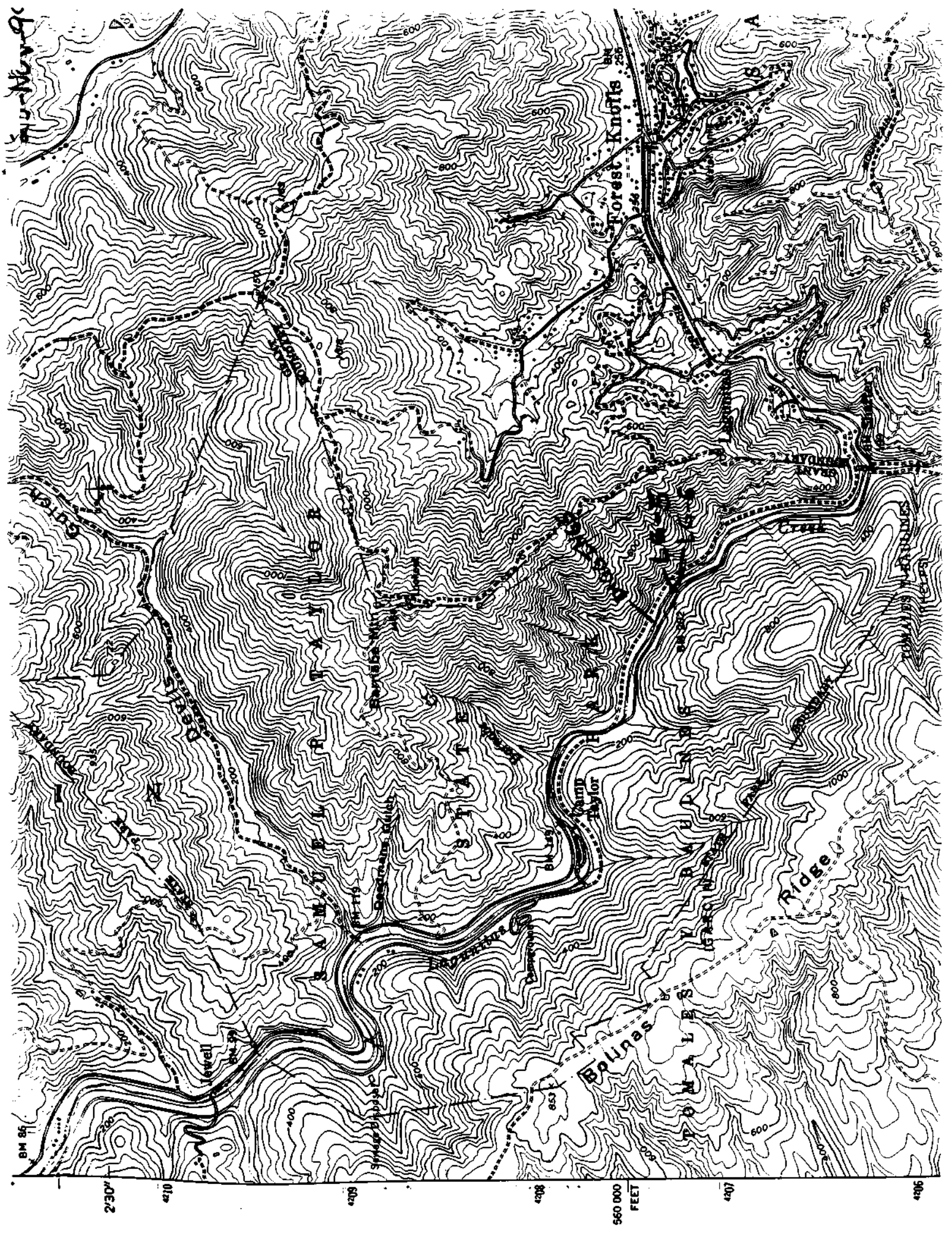


PRUNUSKE CHATHAM, INC.
 P.O. BOX 828
 OCCIDENTAL, CA 95465
 (707) 874-0100

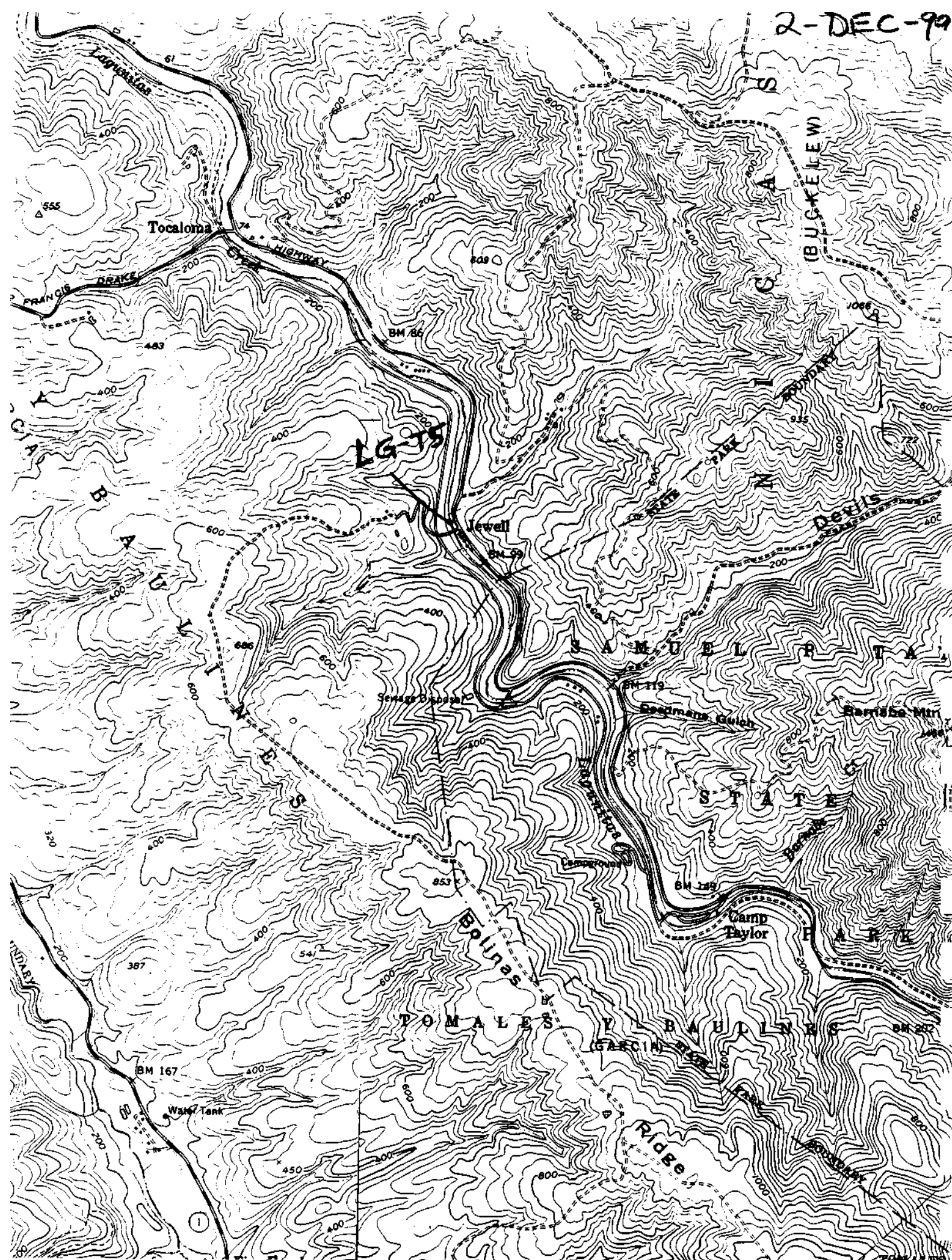
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SCALE:	1" = 3000'
CHECKED BY:	MN
DRAFTED BY:	EA

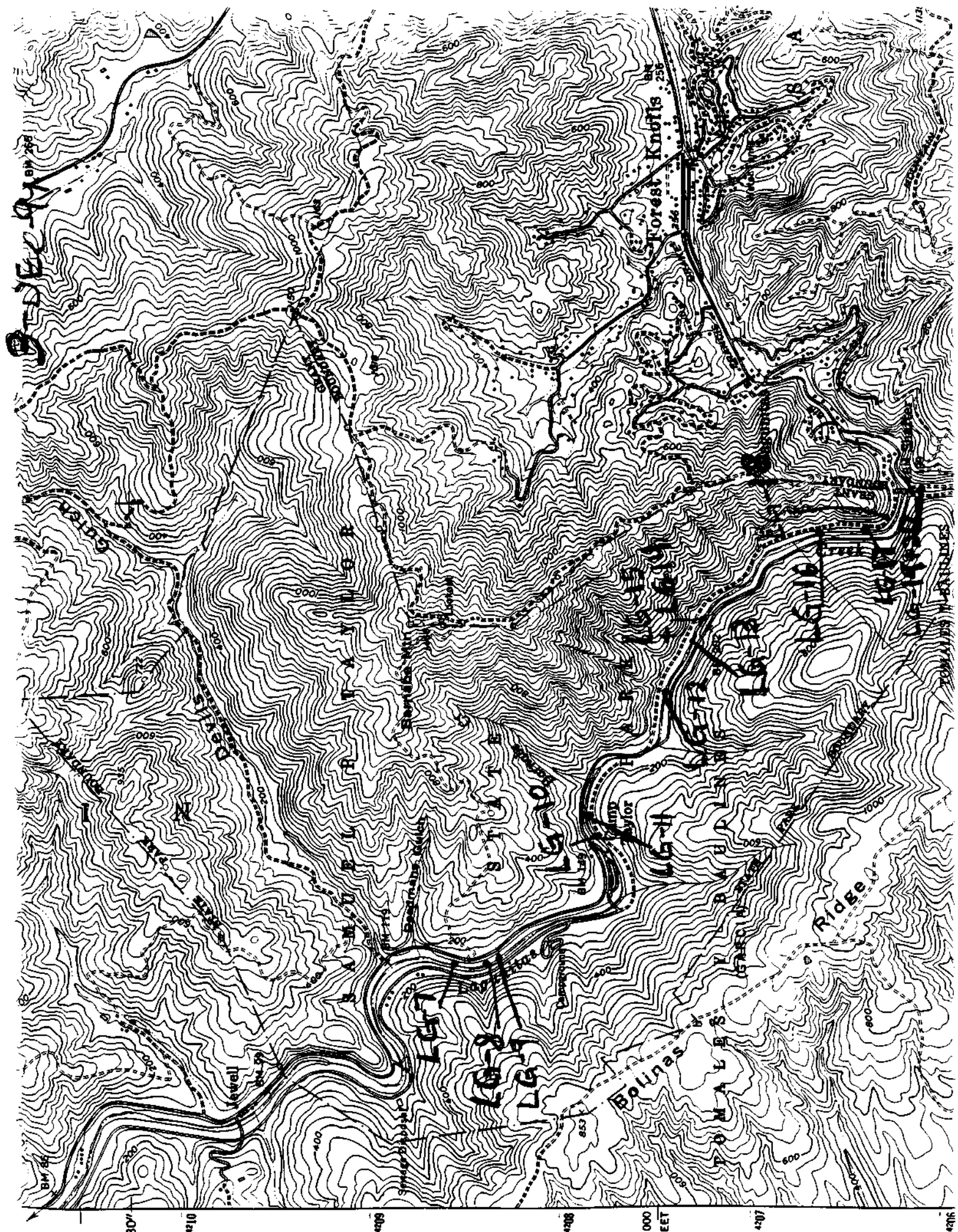
PREPARED BY
 MARIN MUNICIPAL
 WATER DISTRICT

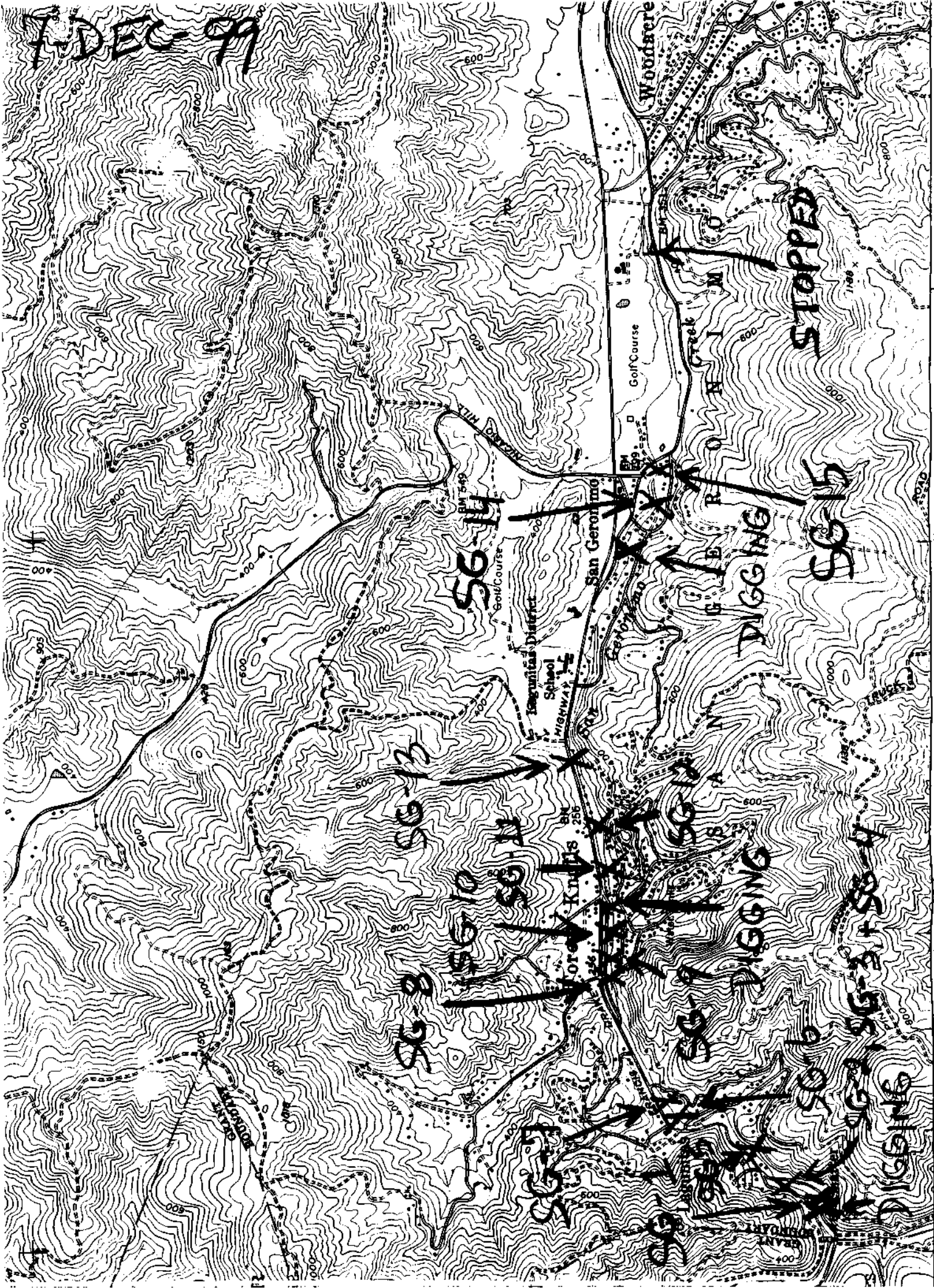
Barren



2-DEC-99



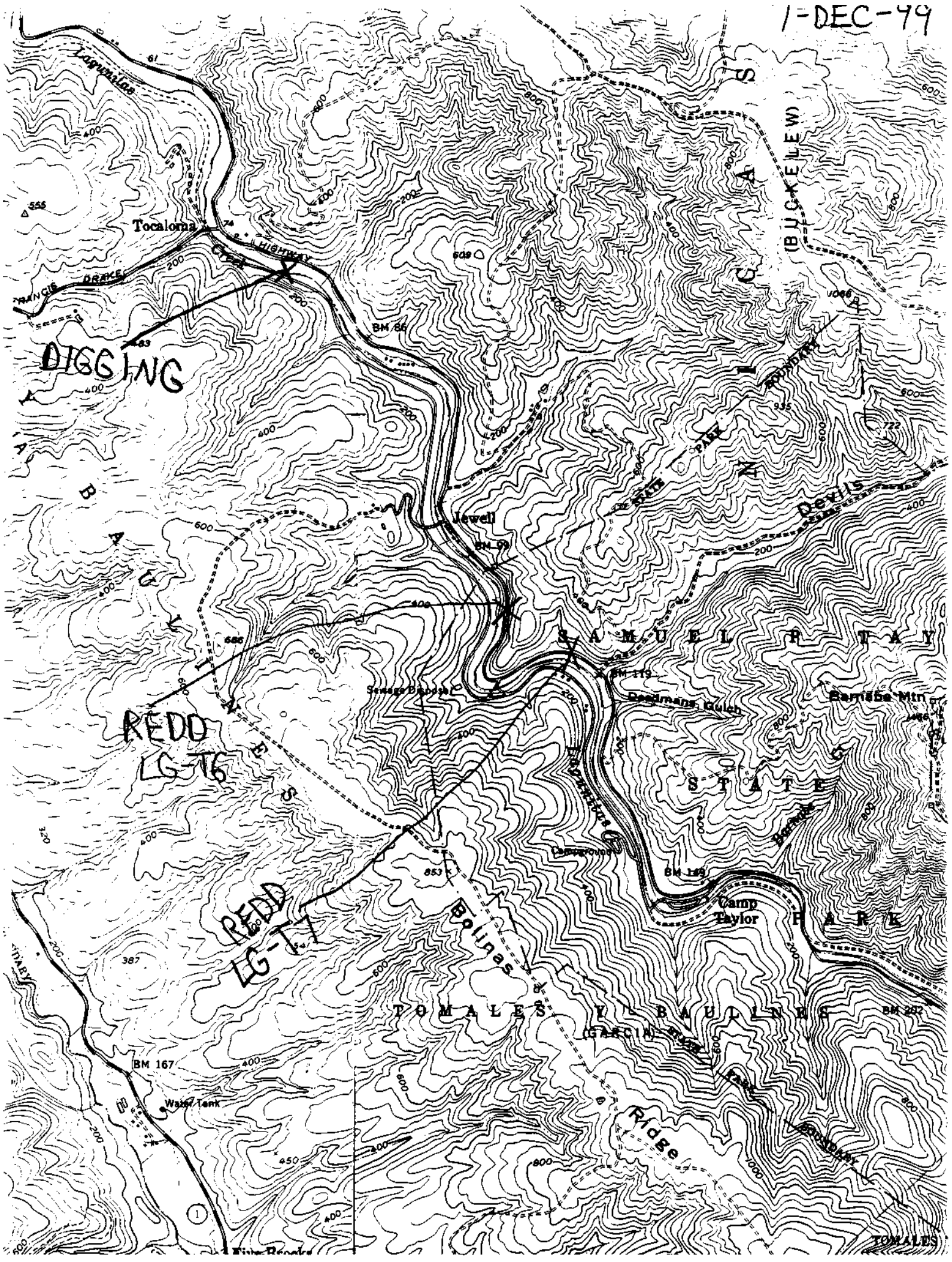




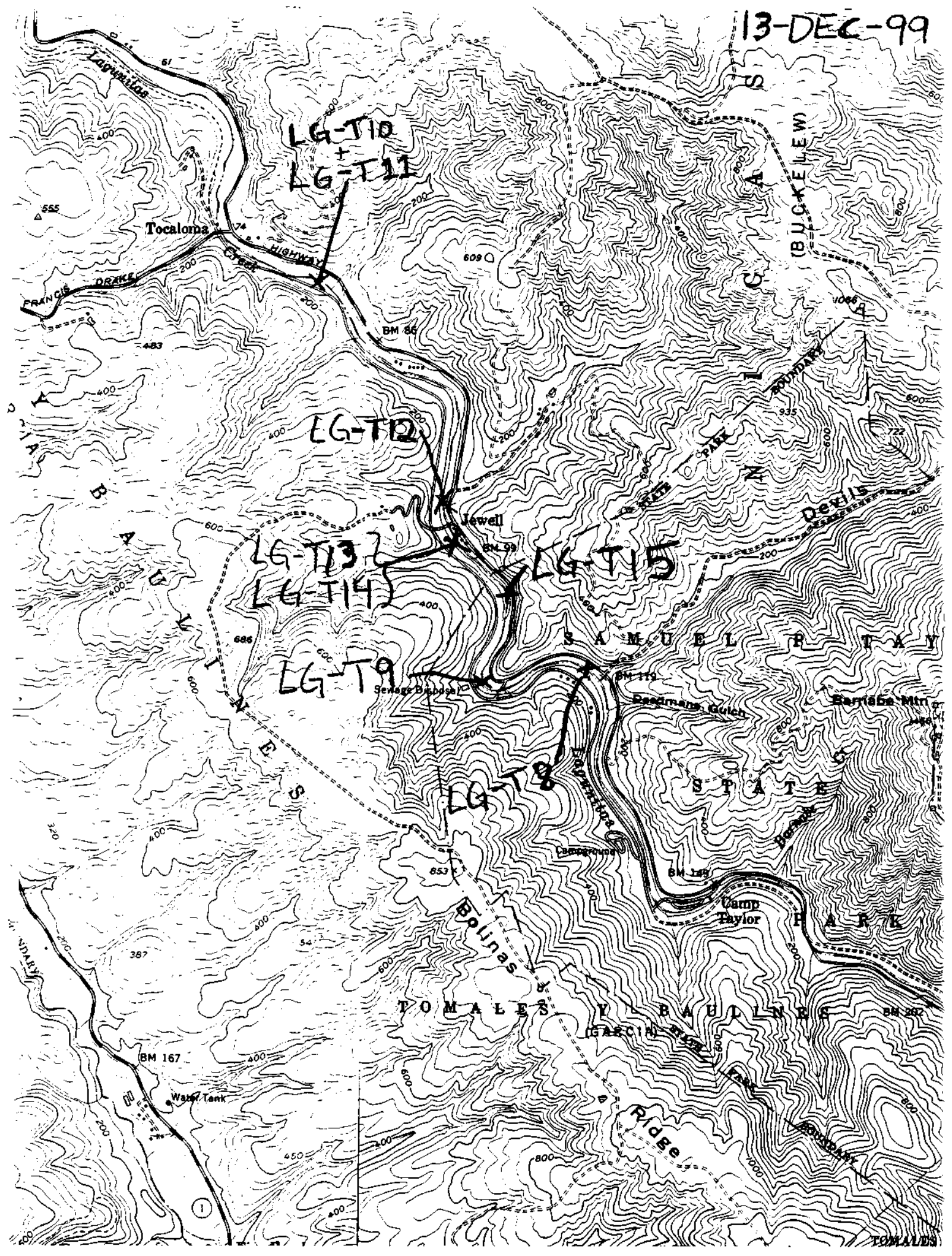
4230' 526 527 (BOLINAS) 1459' NW SCA' - 240'' 528 529 40' INTERIOR-GEOLOGICAL SURVEY, RESTON, VIRGINIA - 1984

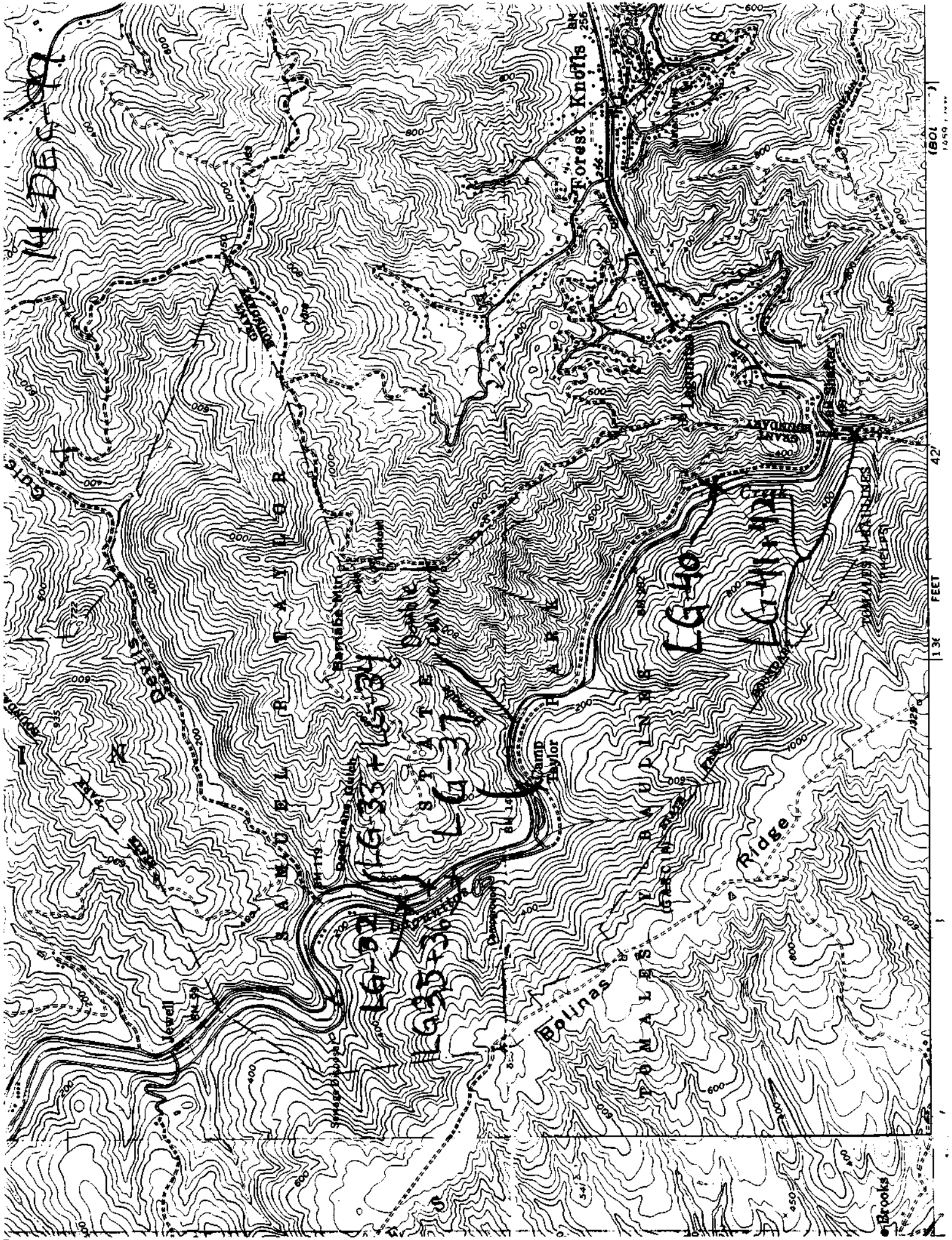
I-DEC-99

1-DEC-79



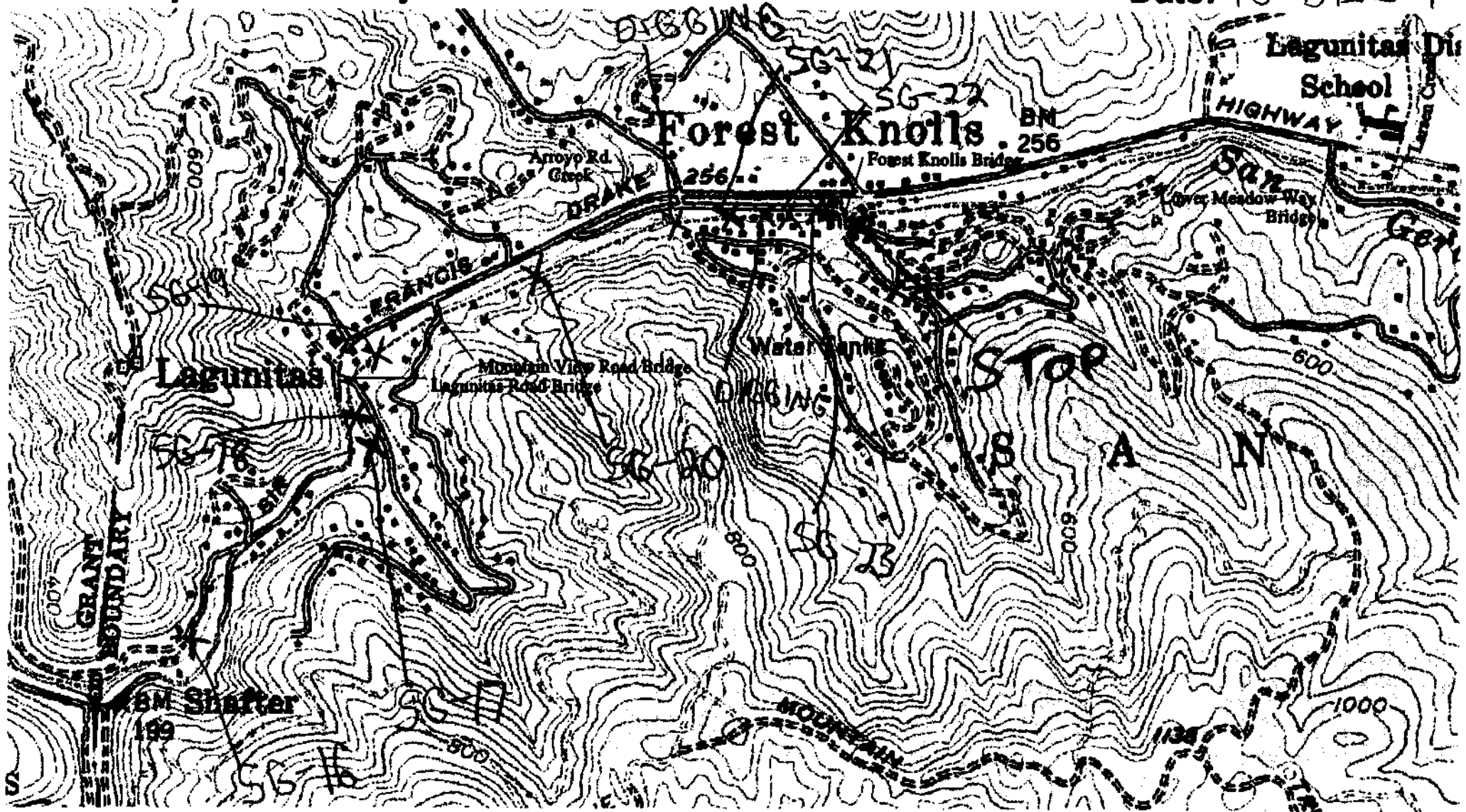
13-DEC-99



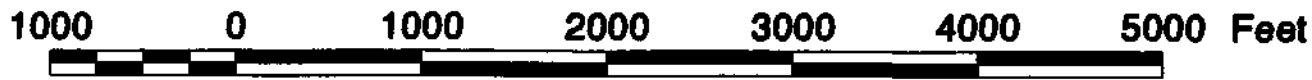


Coho Spawner Survey - Lower San Geronimo Creek

Date: 16-DEC-90



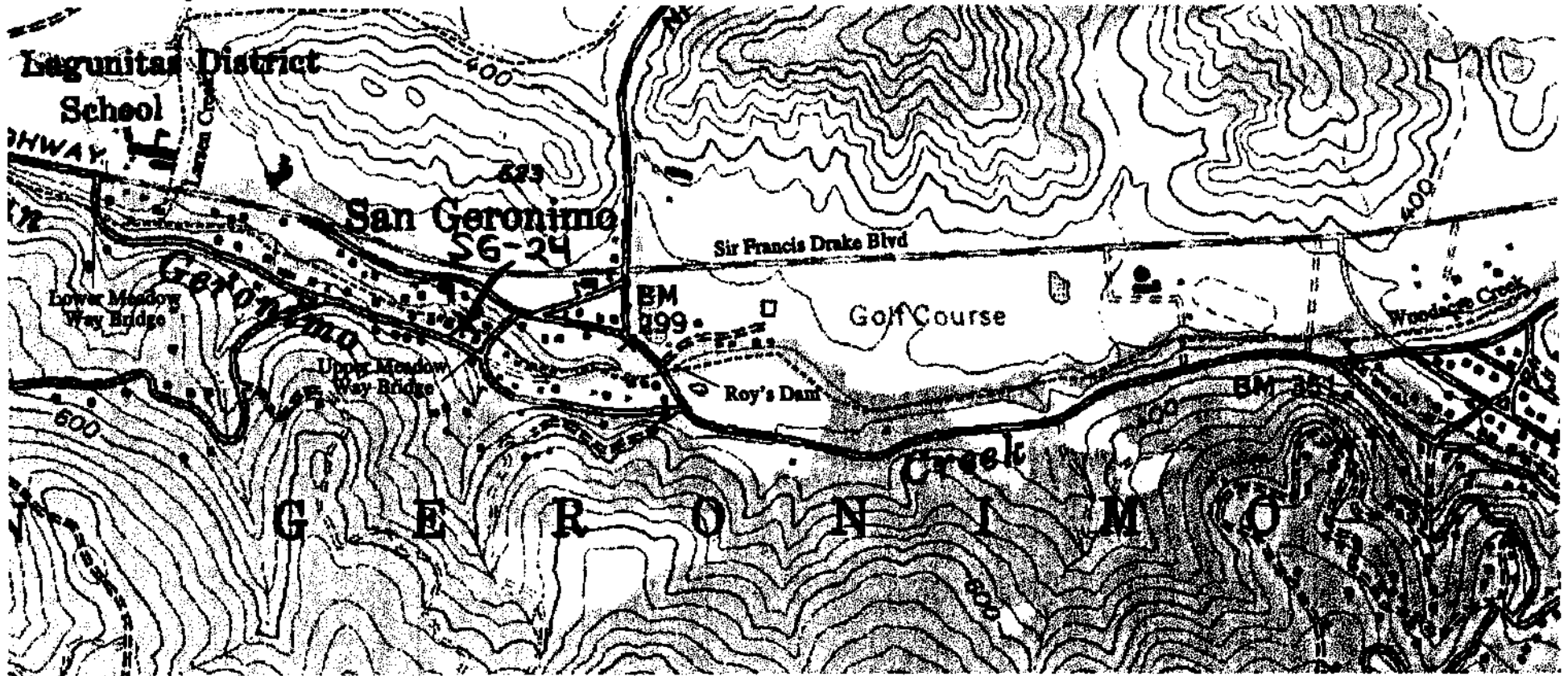
Scale: 1" = 0.20 miles



Start Forest Knolls Bridge

Coho Spawner Survey ^{Upper} **San Geronimo Creek**

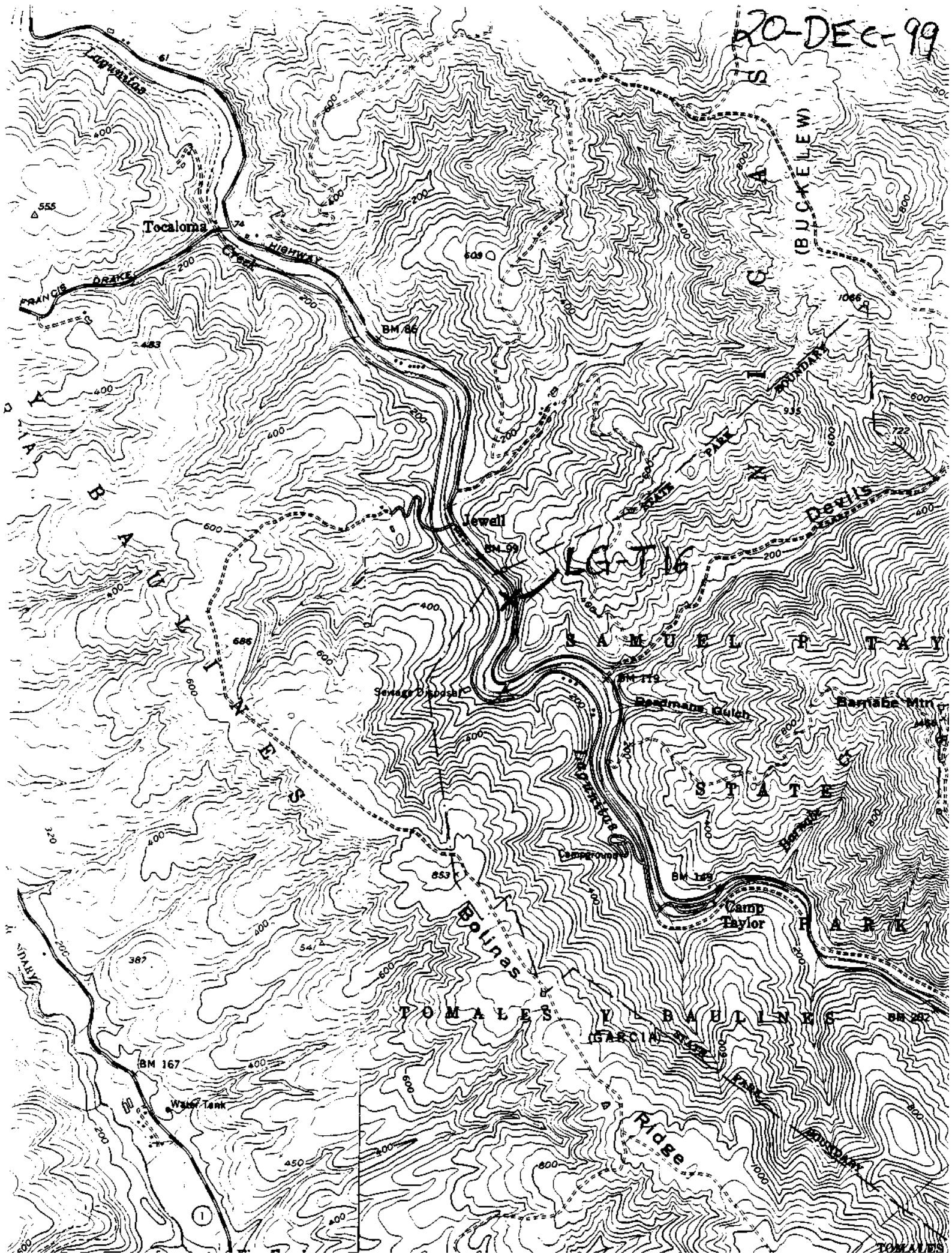
Date: 17-DEC-99



Scale: 1" = 0.20 miles



20-DEC-99



Tocaloma

Lowell

LEG 16

SAMUEL TAYLOR

STATE

Camp Taylor

POLINES

RIDGE

BUCKLELEW

Devil's

Bartaba Mtn

PARK

BM 167

Water Tank

BM 66

BM 69

BM 113

BM 149

BM 202

PRANCIS

DRAKE

HIGHWAY

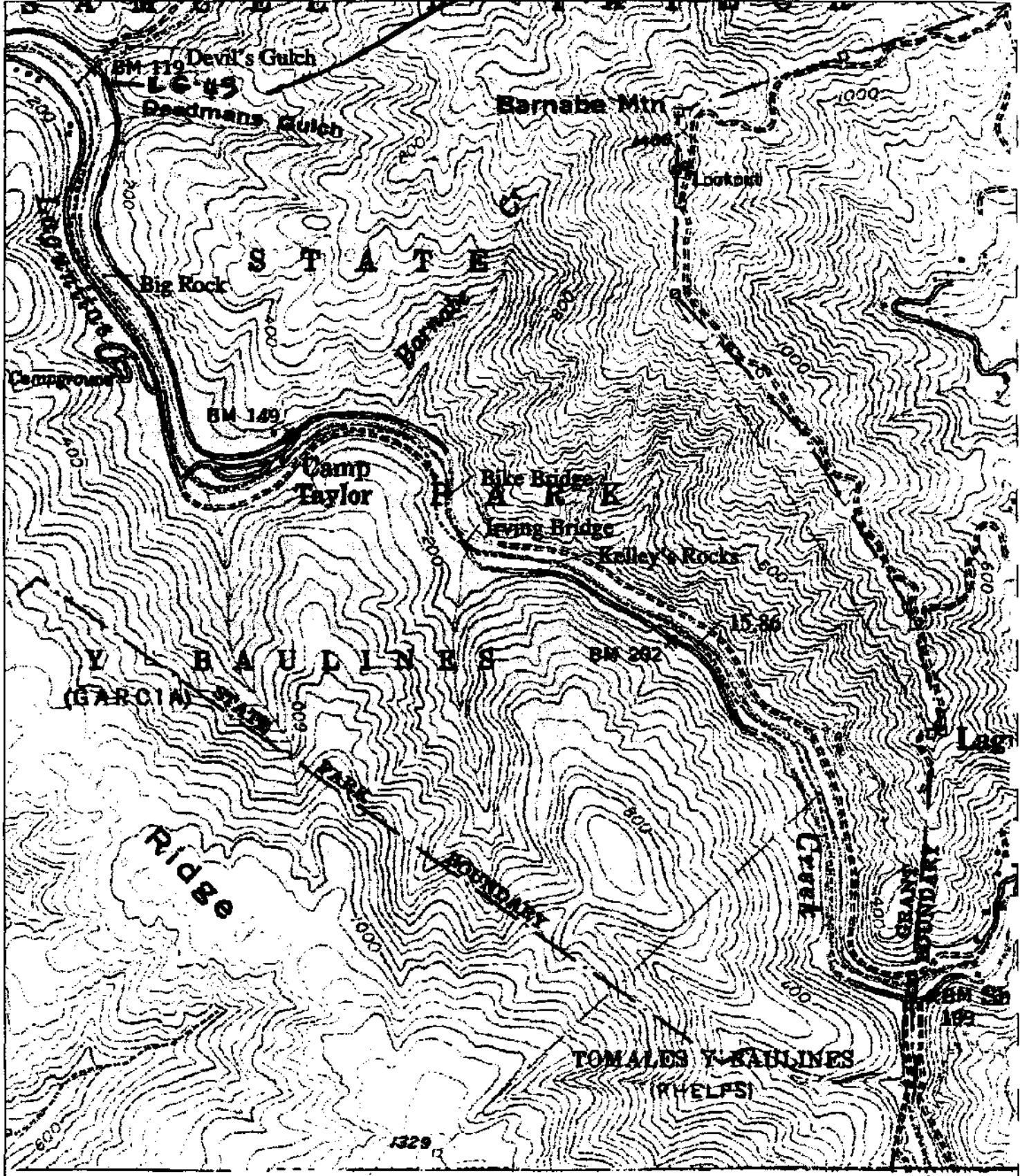
Devil's Gulch

STAIRWAY

TOMALOMA

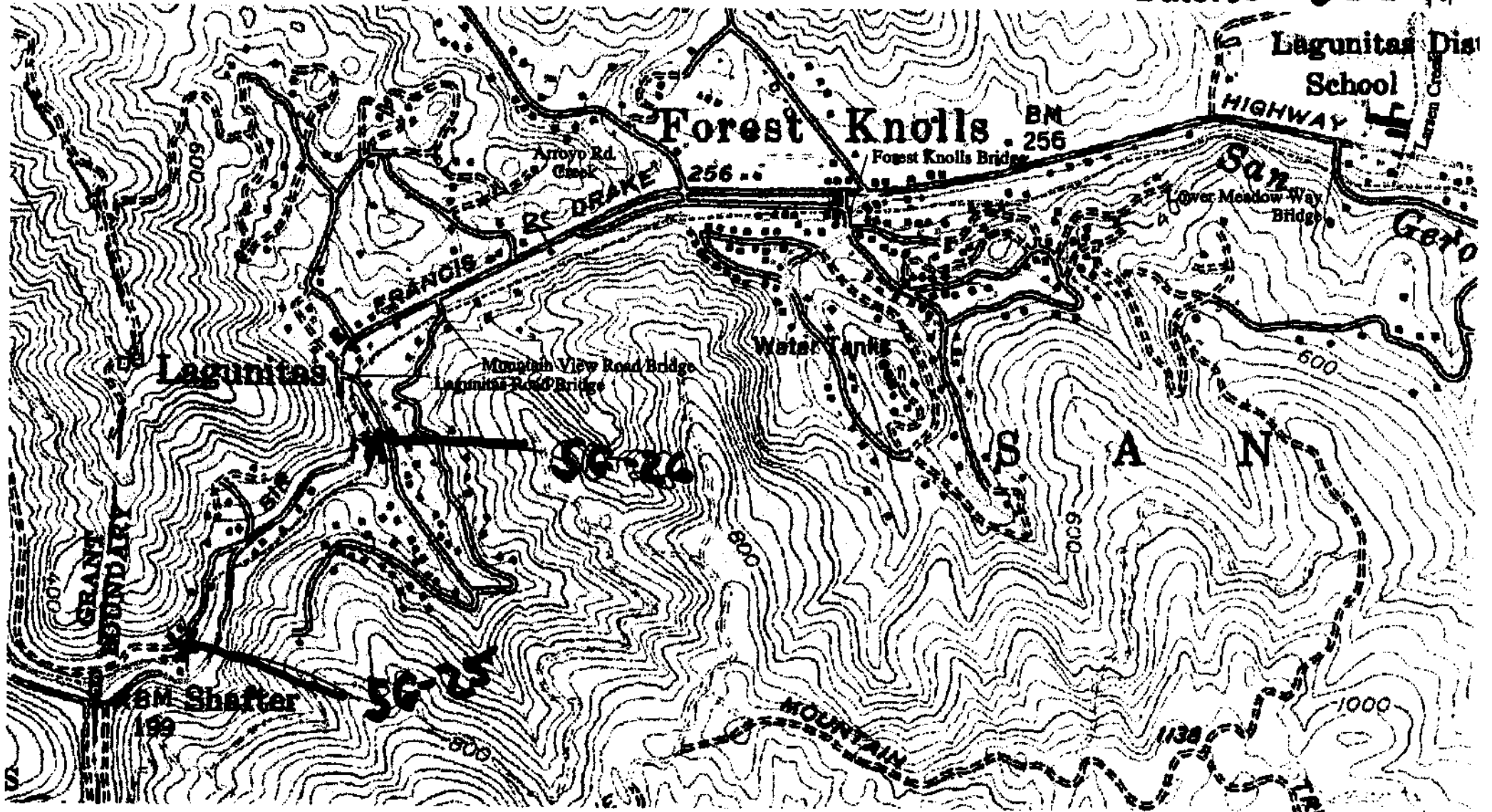
Coho Spawner Survey Devil's Gulch to Shafter Dam

Date: 22 DEC 99



Coho Spawner Survey - Lower San Geronimo Creek

Date: 27-DEC-99

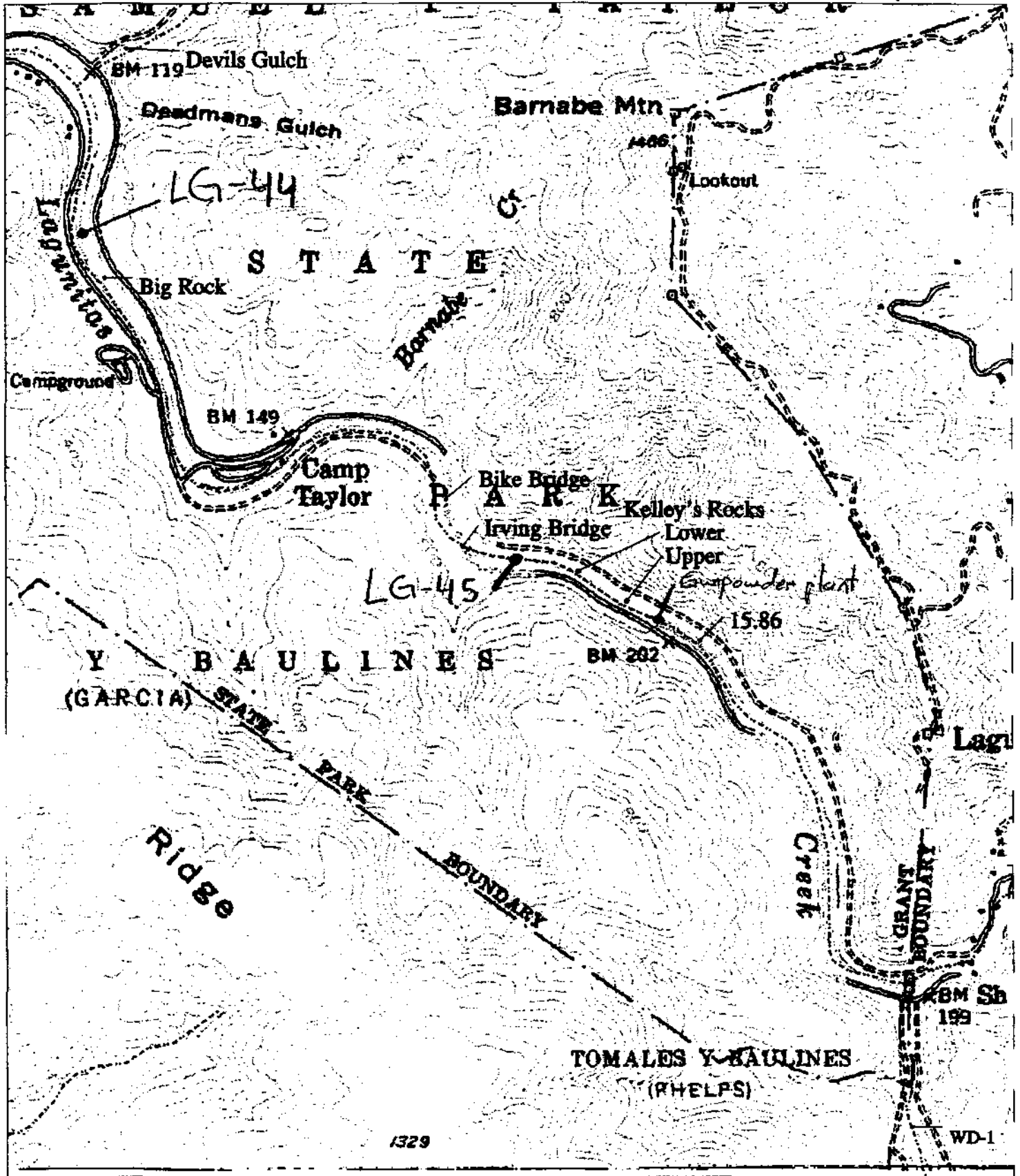


Scale: 1" = 0.20 miles



Coho Spawner Survey Devil's Gulch to Shafter Dam

Date: 29-DEC-99

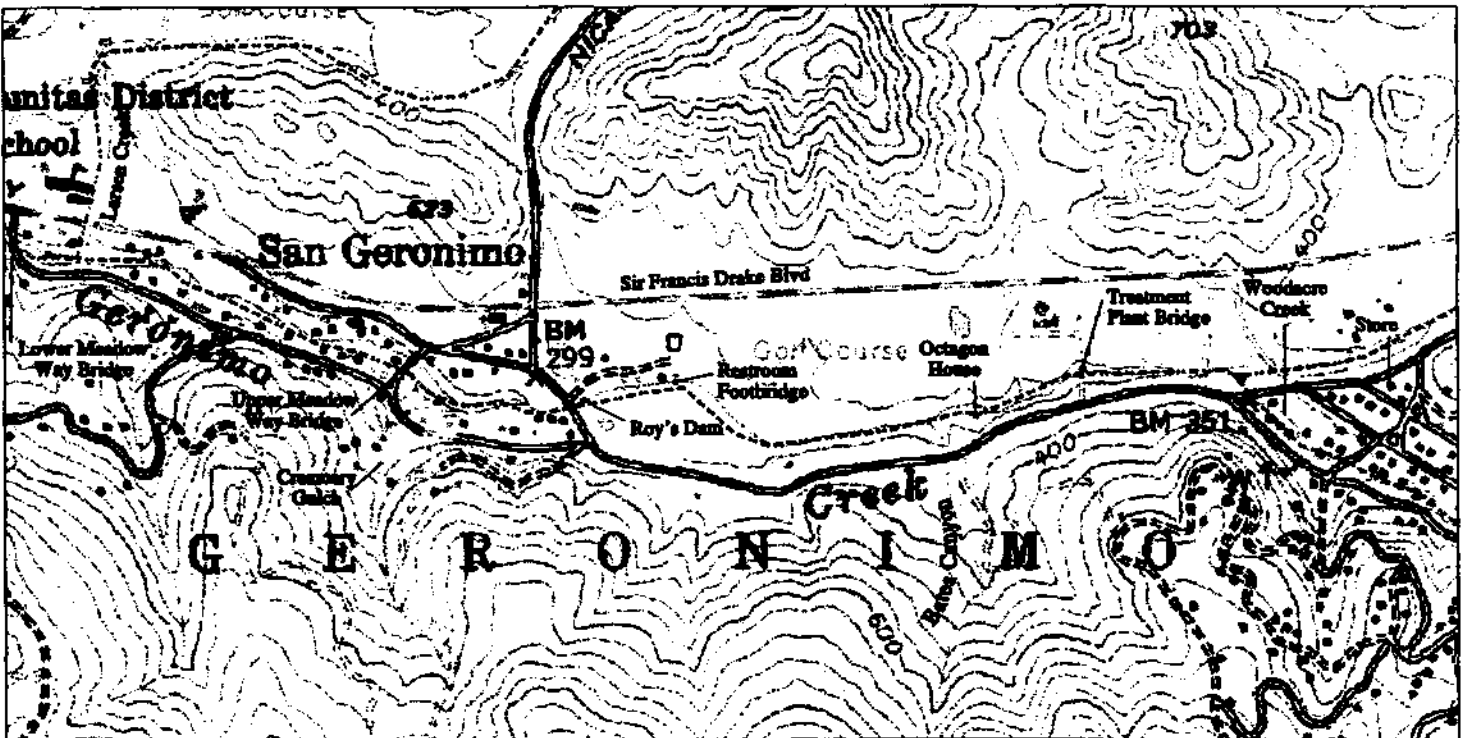
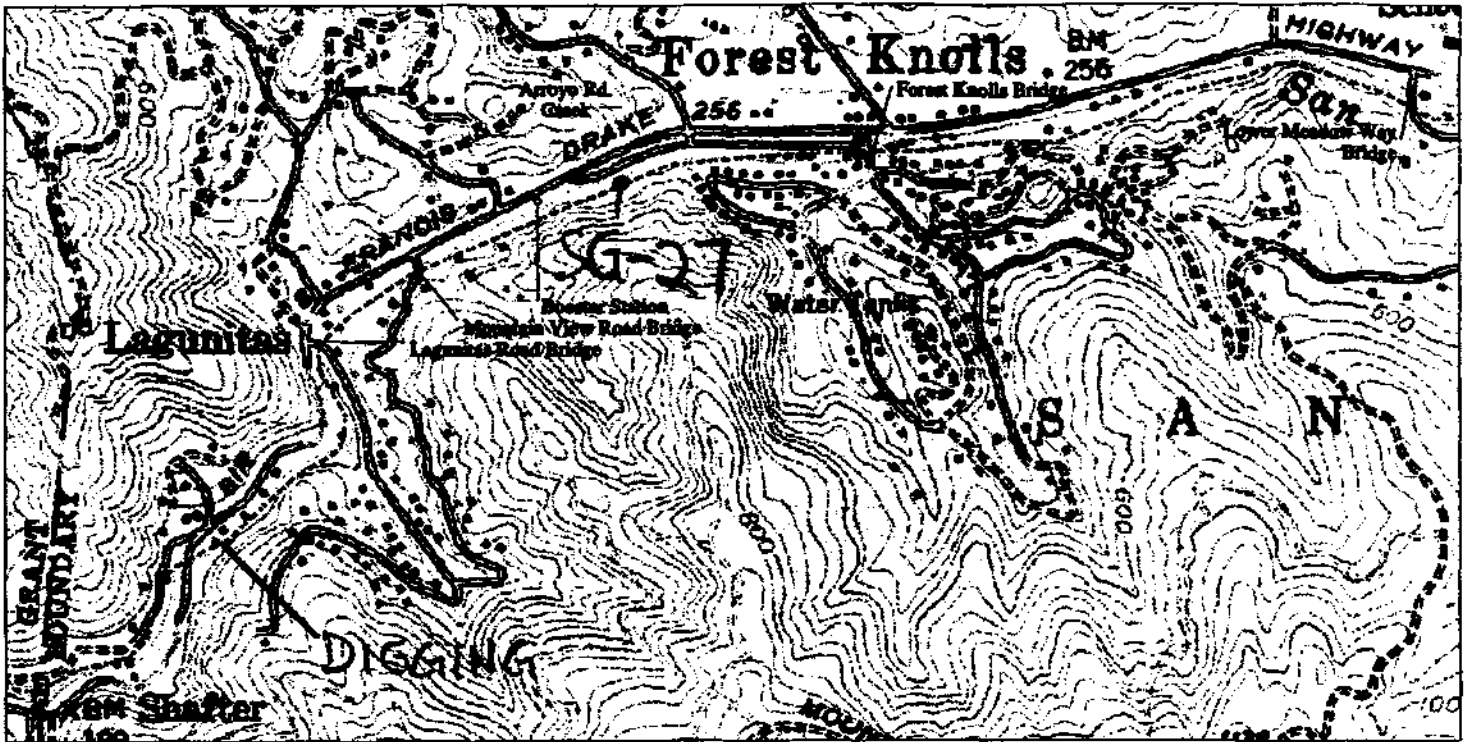


Scale: 1" = 0.25 miles
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Coho Spawner Survey San Geronimo Creek

Date: 5-JAN-00

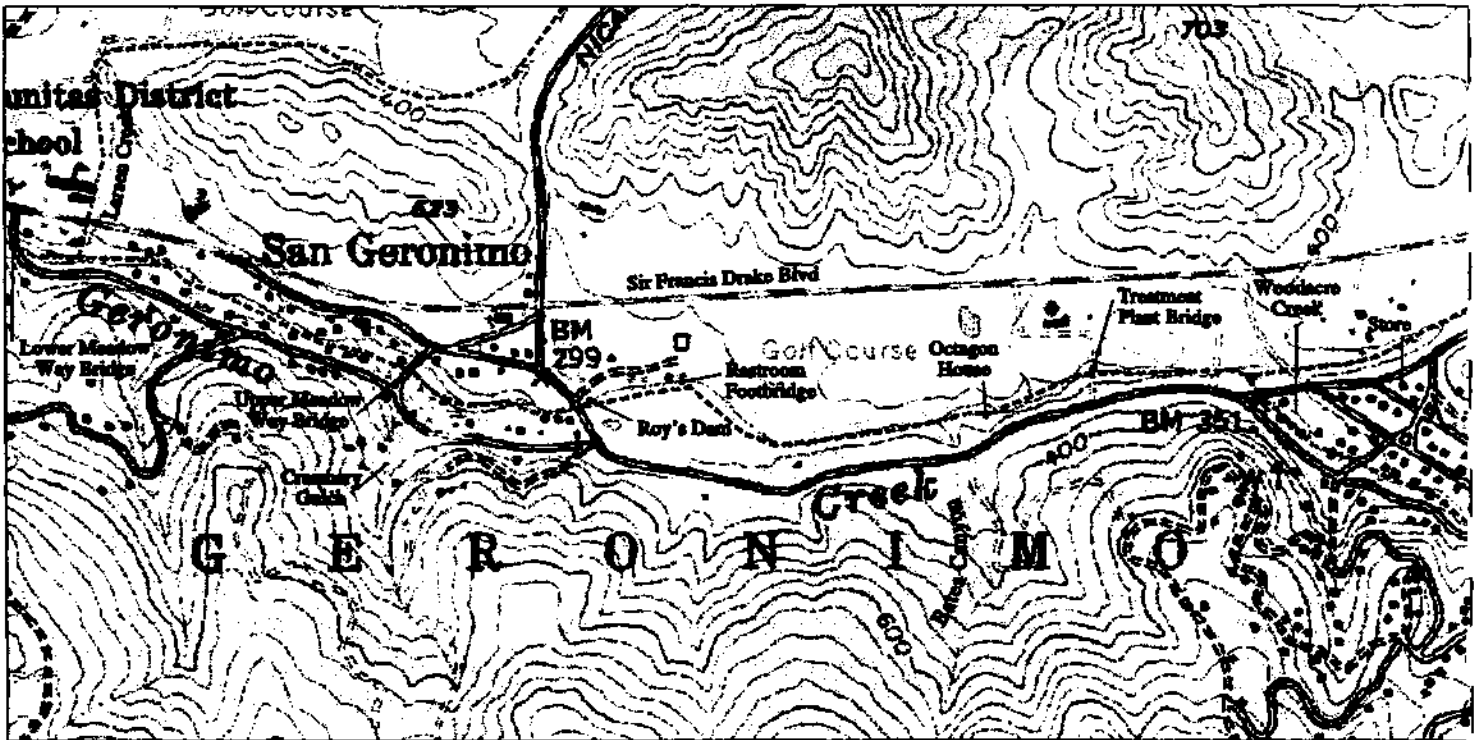
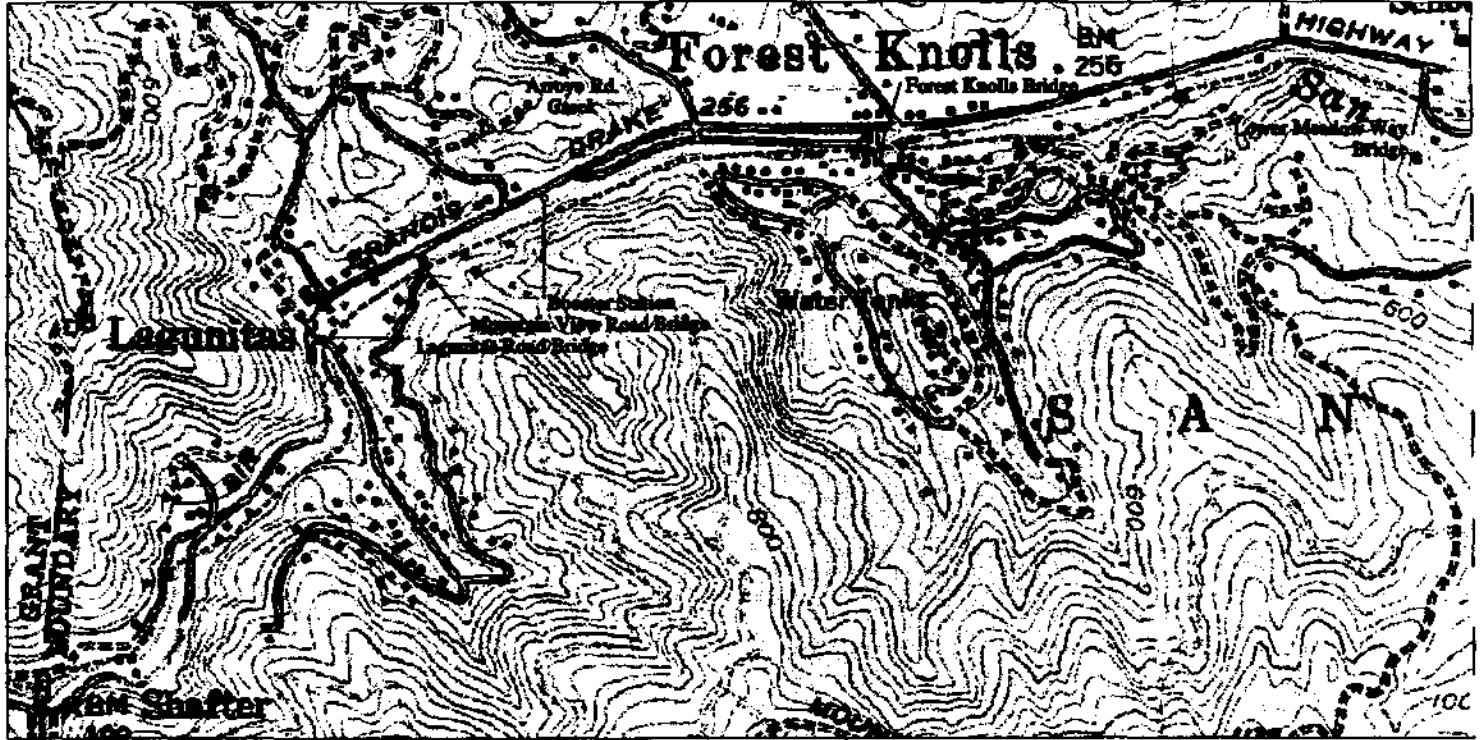


Scale: 1" = 0.25 miles



Coho Spawner Survey San Geronimo Creek

Date: 6-JAN-00
SG-28



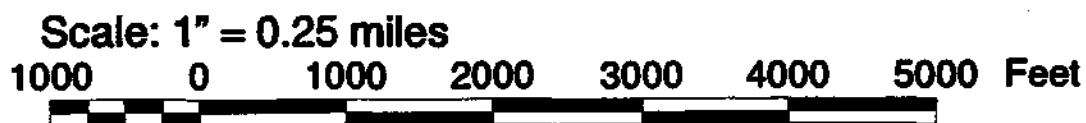
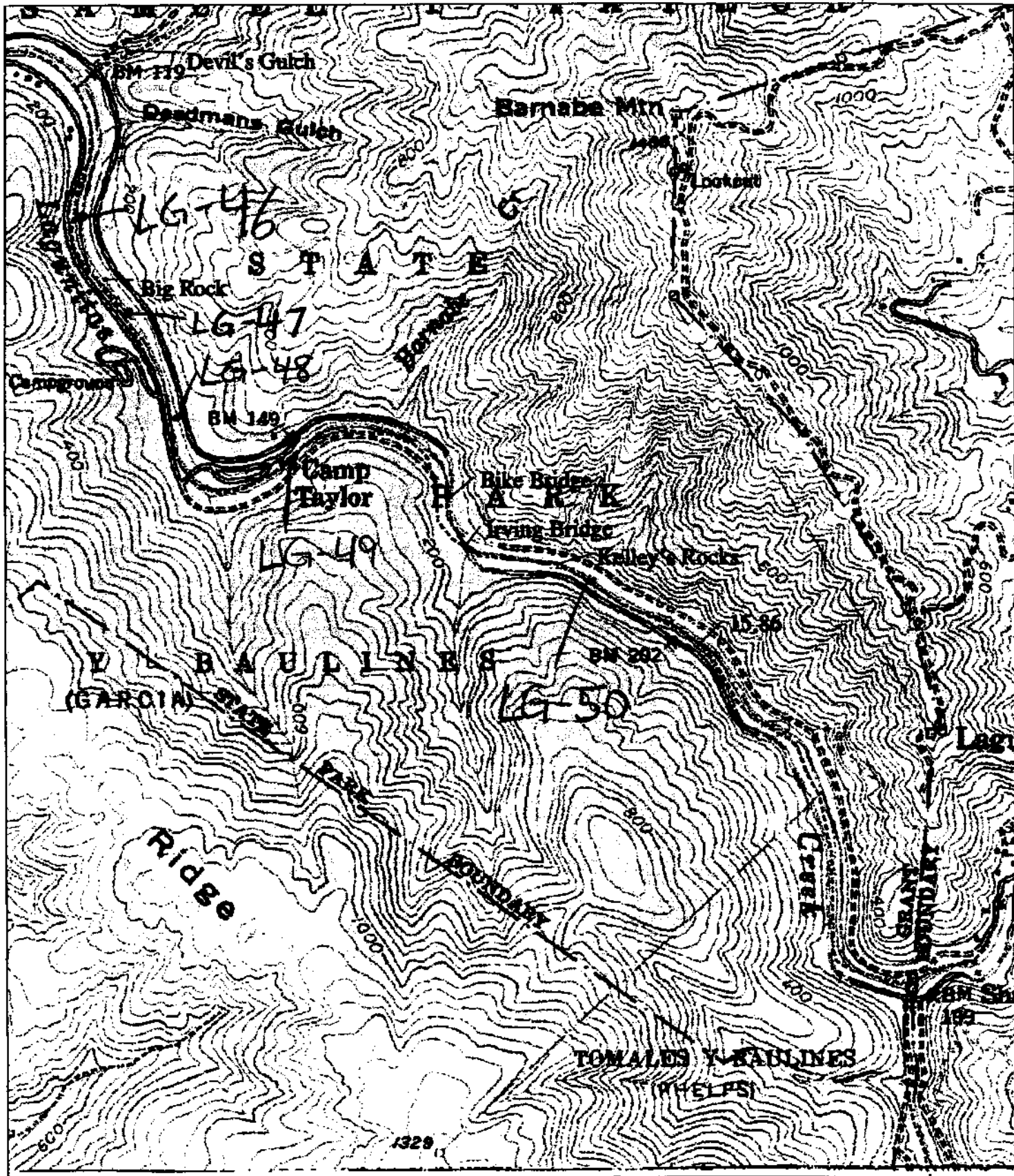
Scale: 1" = 0.25 miles

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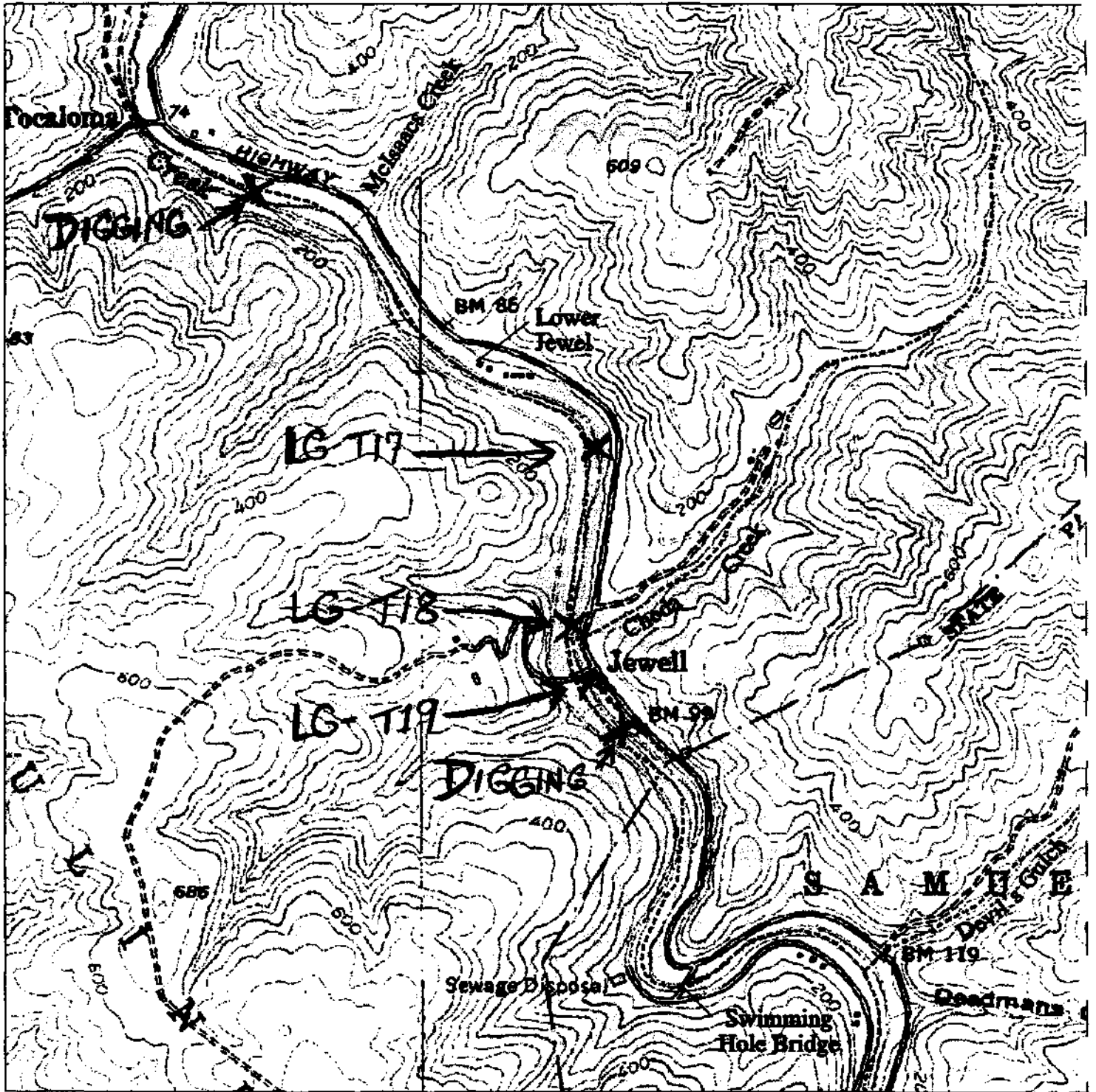
Coho Spawner Survey Devil's Gulch to Shafter Dam

Date: ^{JAN} 7-~~DEC~~ 00



Coho Spawner Survey
Tocaloma to Devil's Gulch

Date: 7-JAN-07

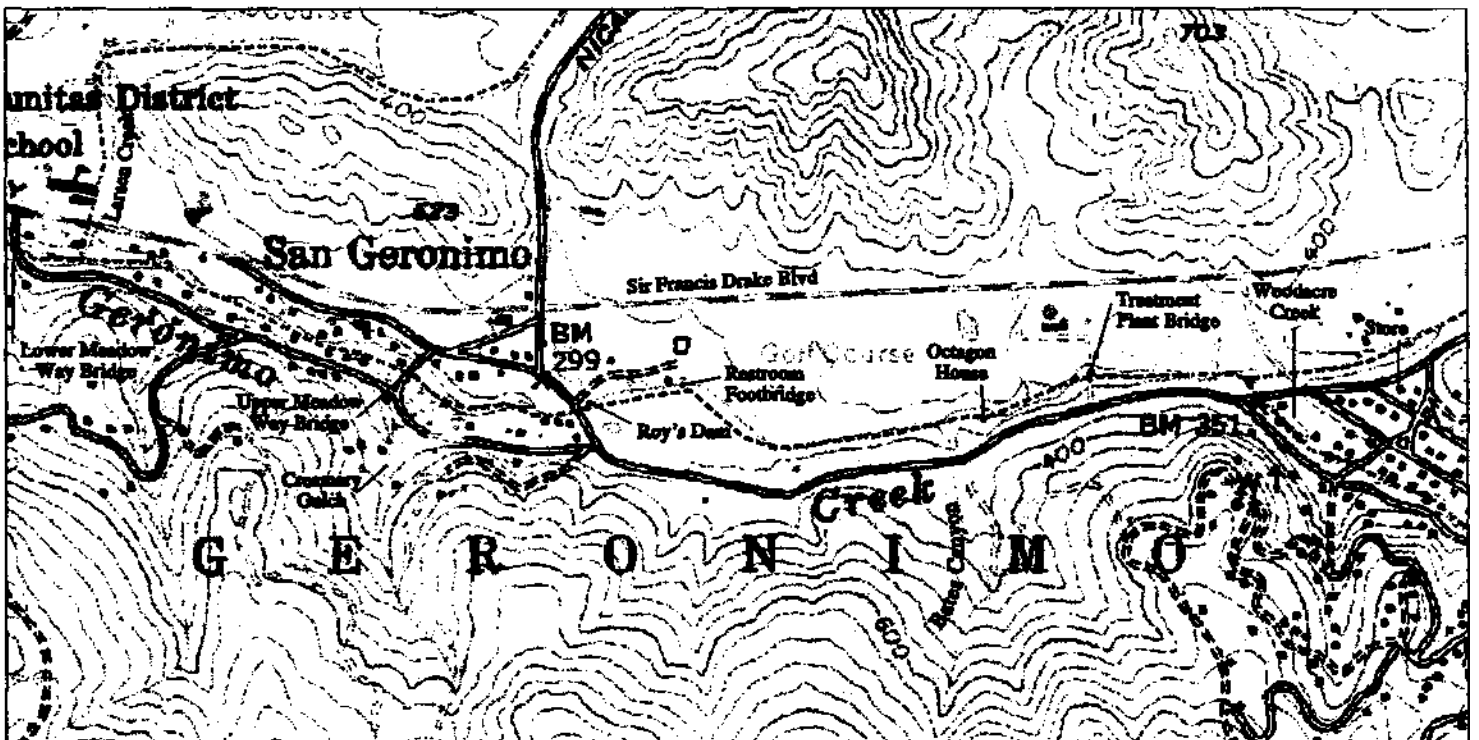
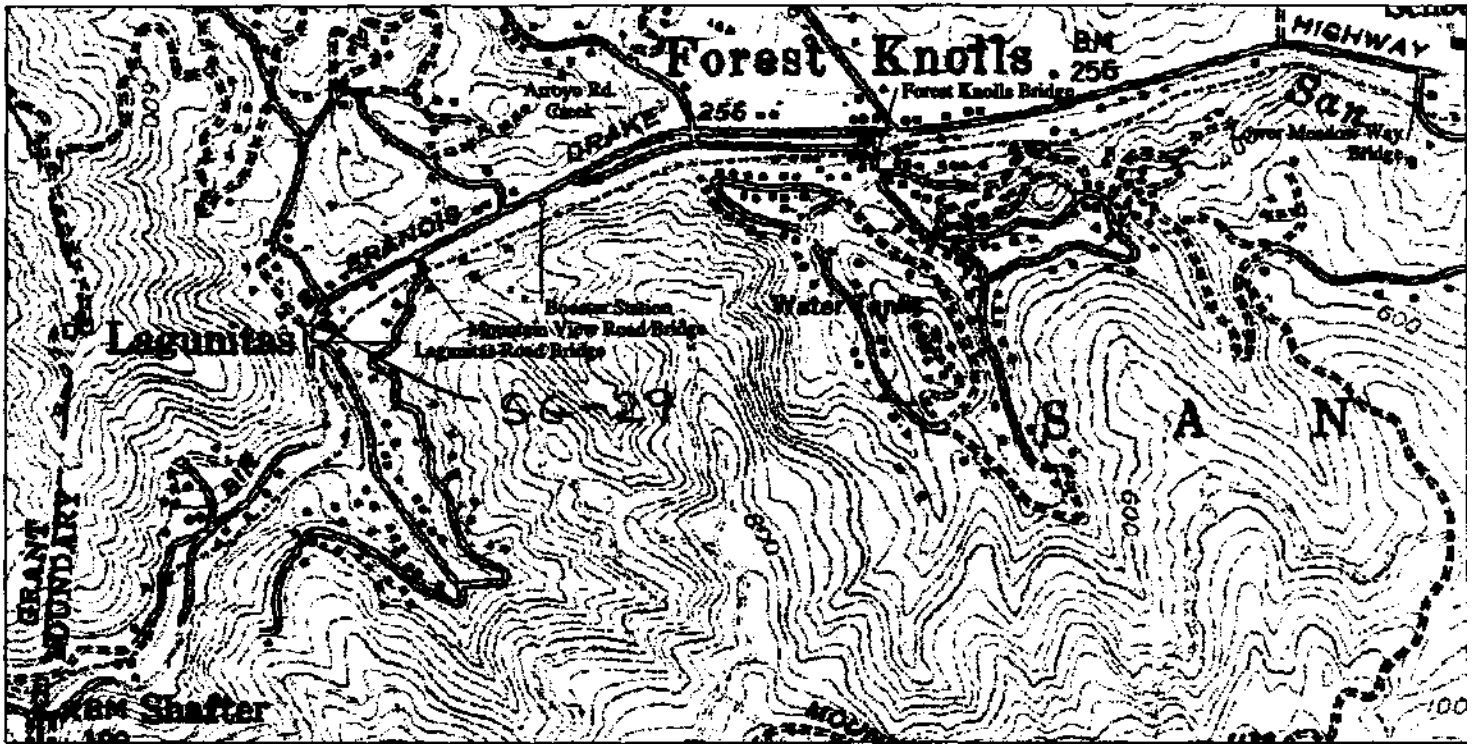


Scale: 1" = 0.25 miles
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Coho Spawner Survey San Geronimo Creek

Date: 10-JAN-00



Scale: 1" = 0.25 miles

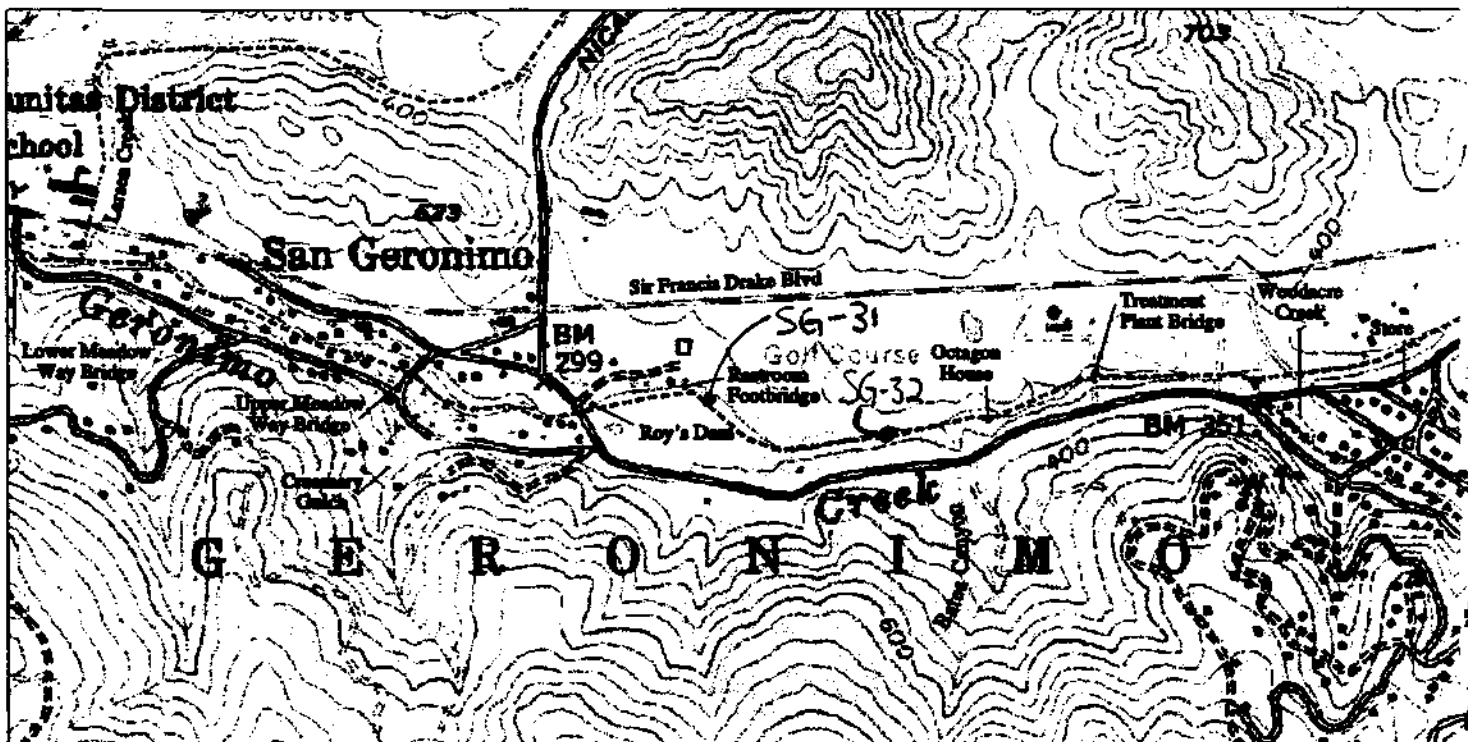
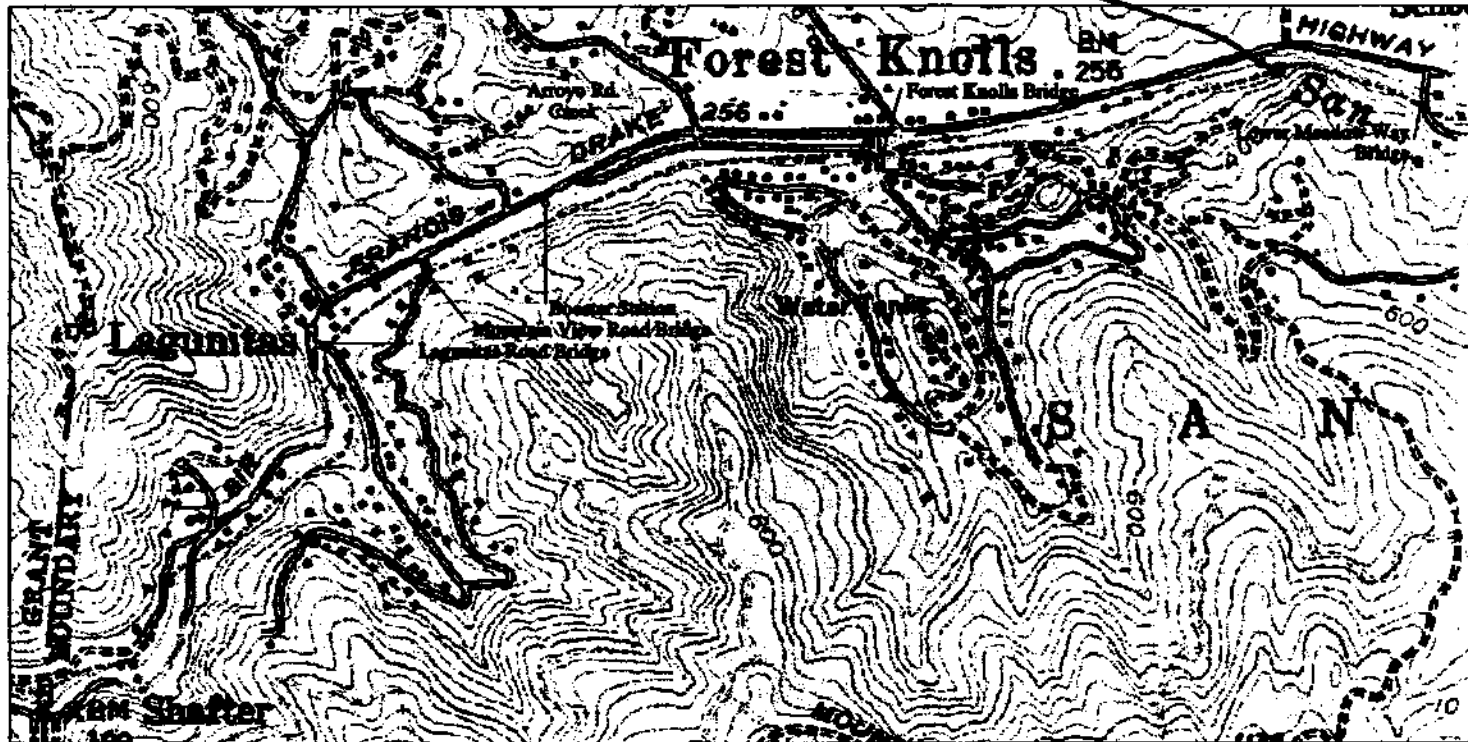
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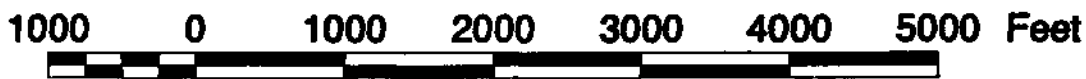
Coho Spawner Survey San Geronimo Creek

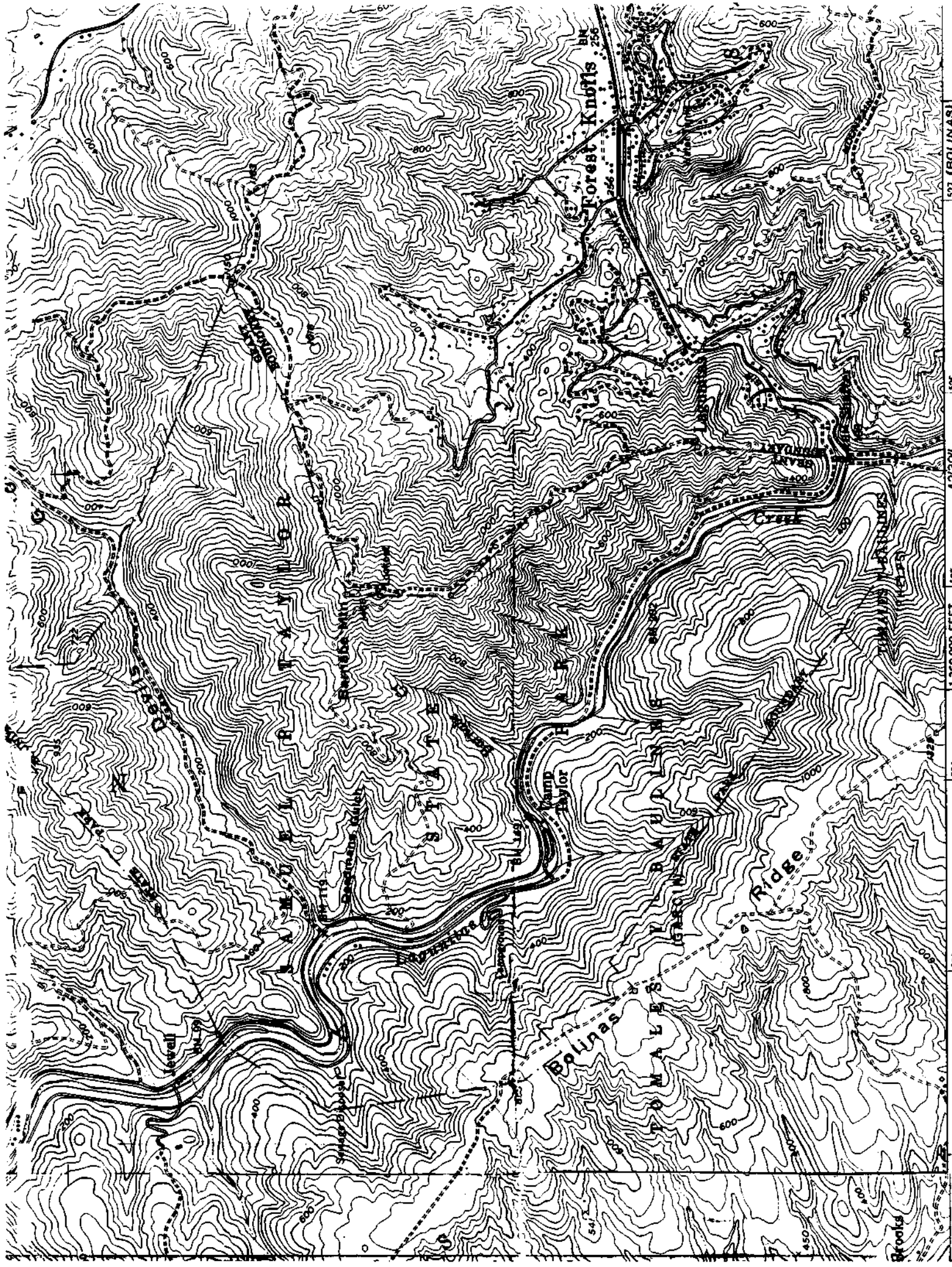
Date: 12-JAN-00

SG-30



Scale: 1" = 0.25 miles





177°45'

1923

1924

1360,000 FEET

1925

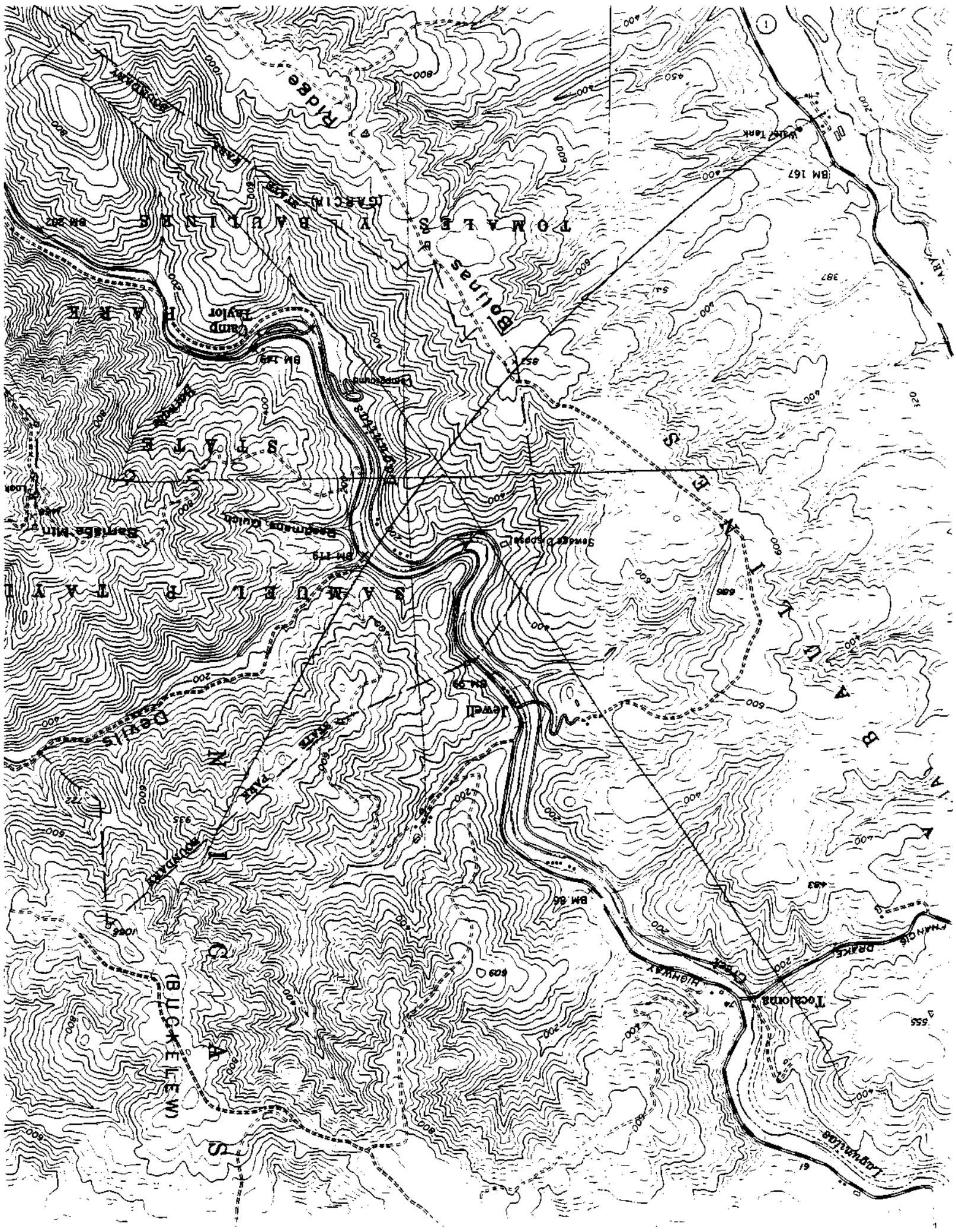
42°30'

1926

1927 (BOLINAS)

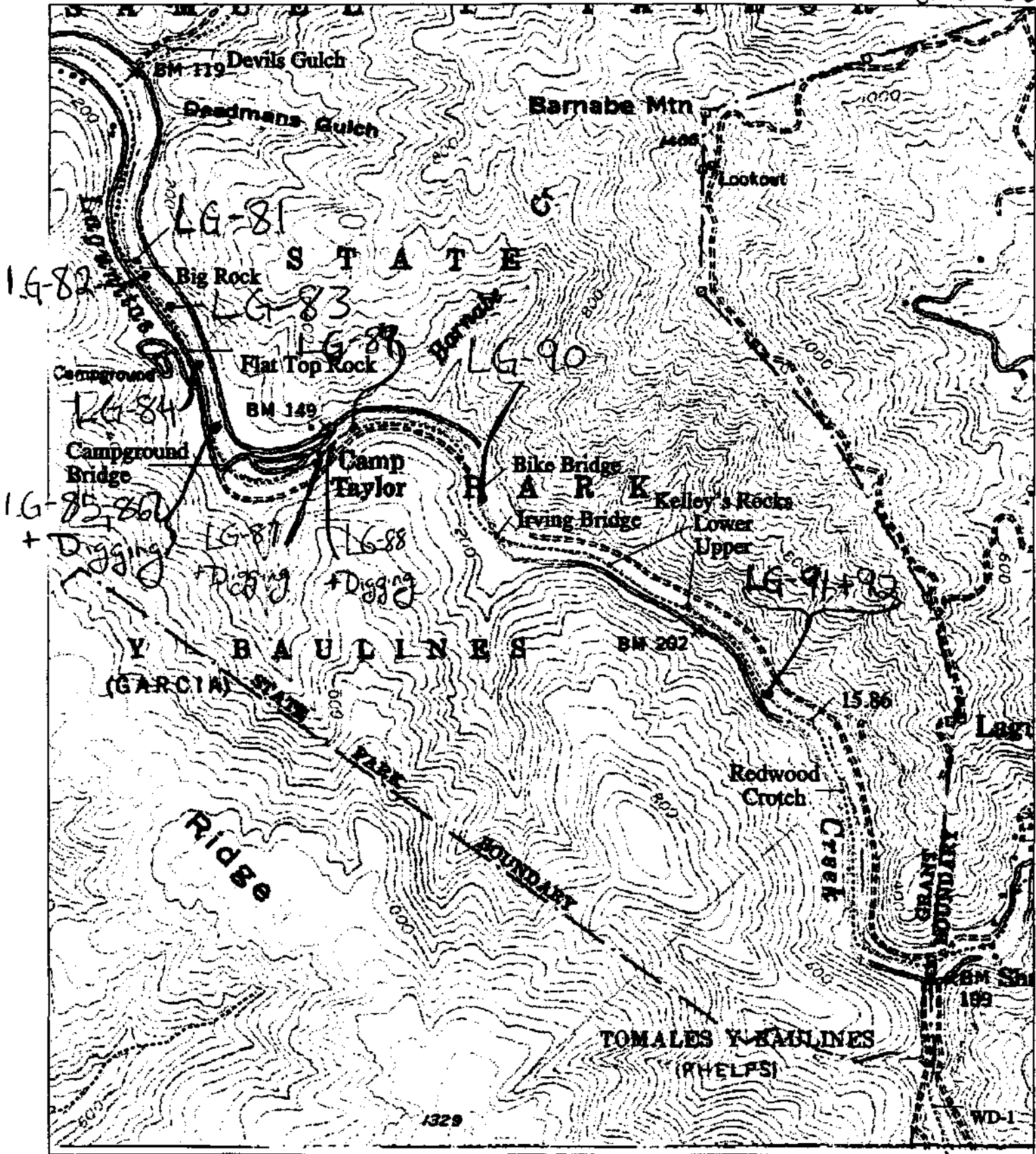
1459 1 NW

1928



**Coho Spawner Survey
Devil's Gulch to Peter's Dam**

Date: 20-JAN-00

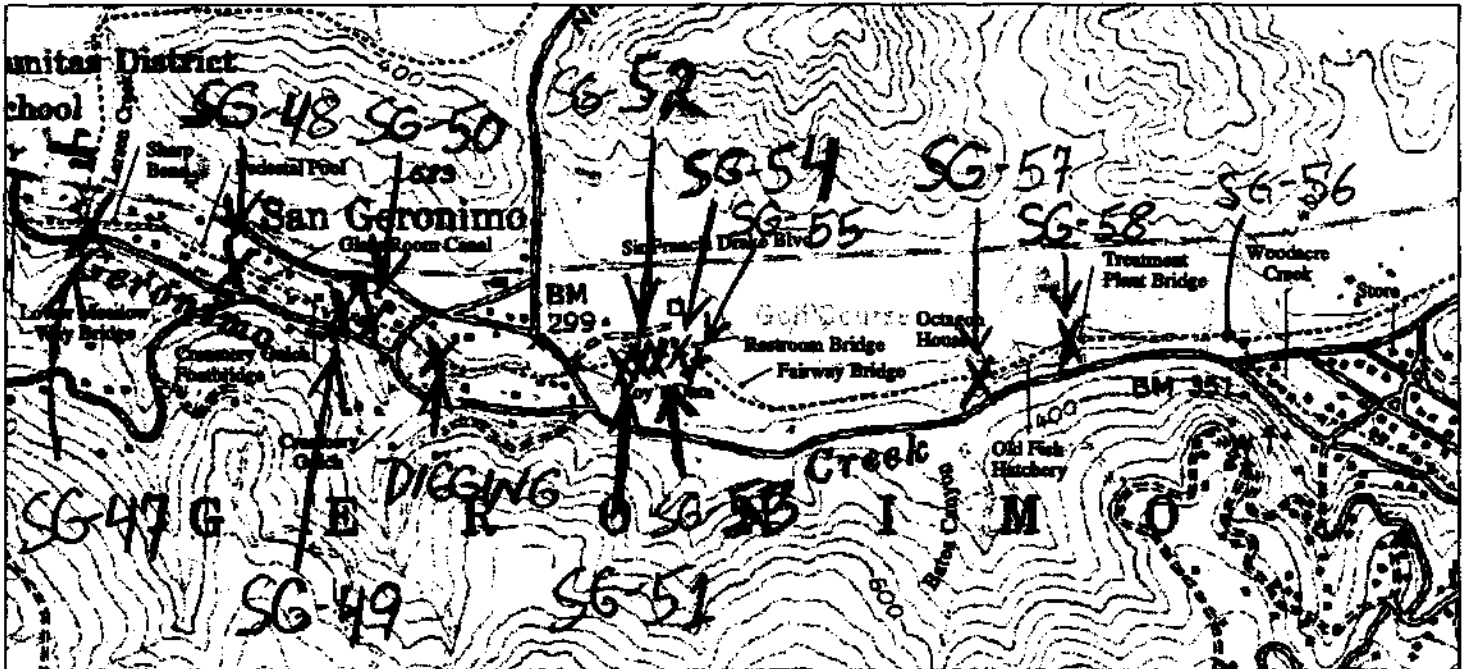


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Coho Spawner Survey San Geronimo Creek

Date: 21-JAN-00



Scale: 1" = 0.25 miles

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Coho Spawner Survey Tocaloma to Devil's Gulch

Date: 21-JAN-01



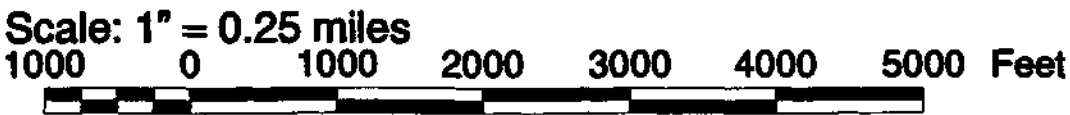
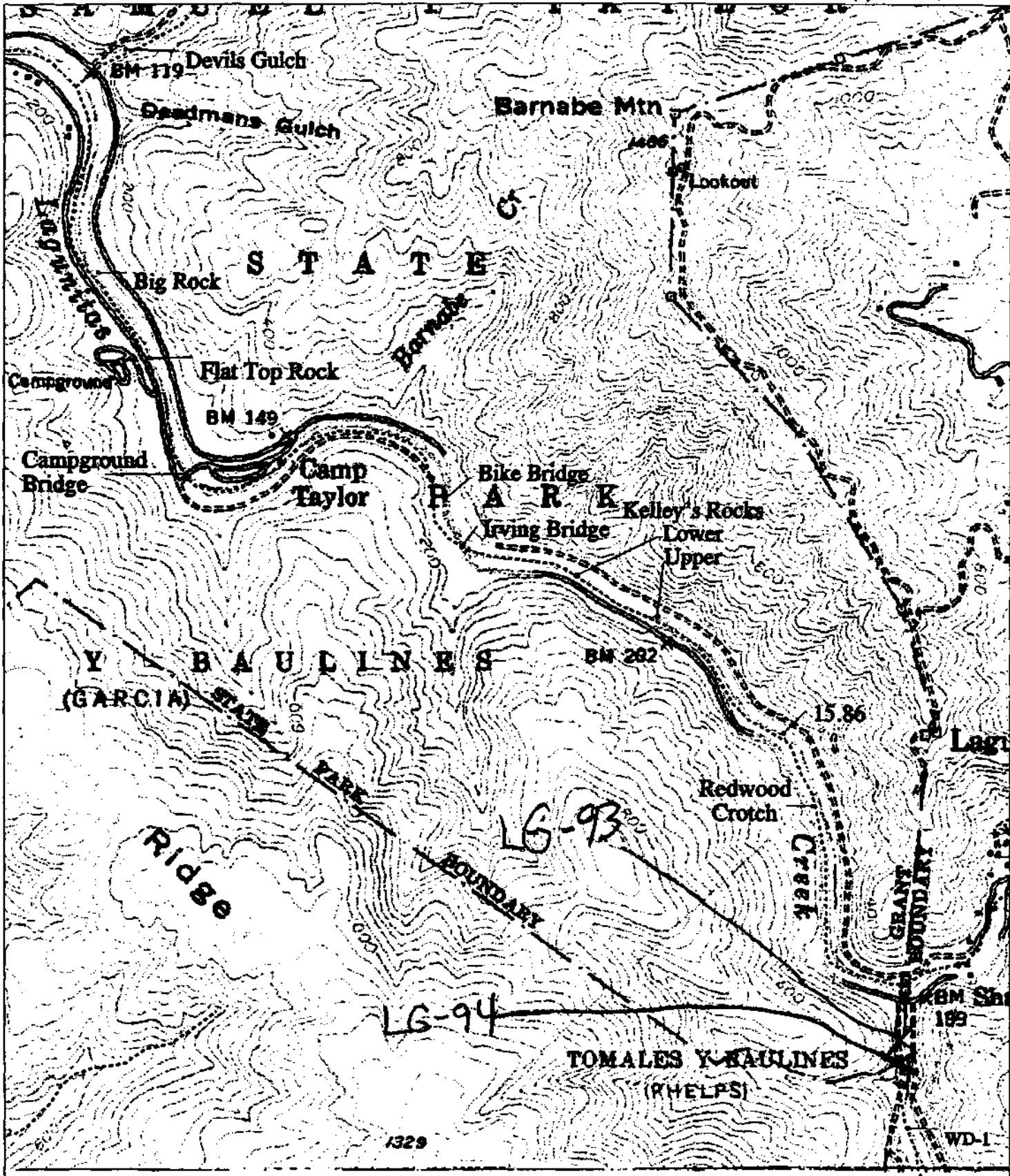
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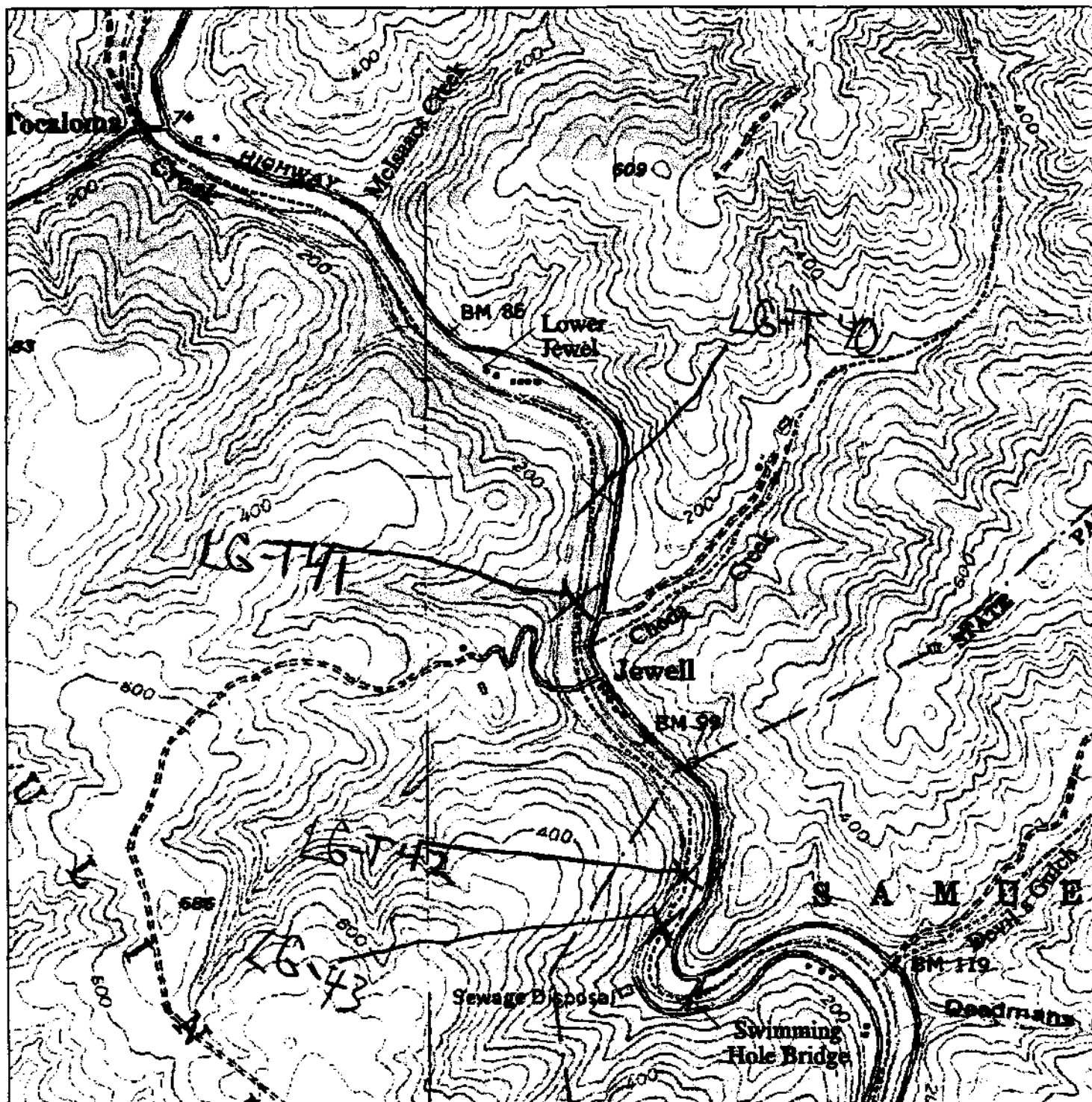
**Coho Spawner Survey
Devil's Gulch to Peter's Dam**

Date: 21-JAN-06



Coho Spawner Survey Tocaloma to Devil's Gulch

Date: 27-JAN-0

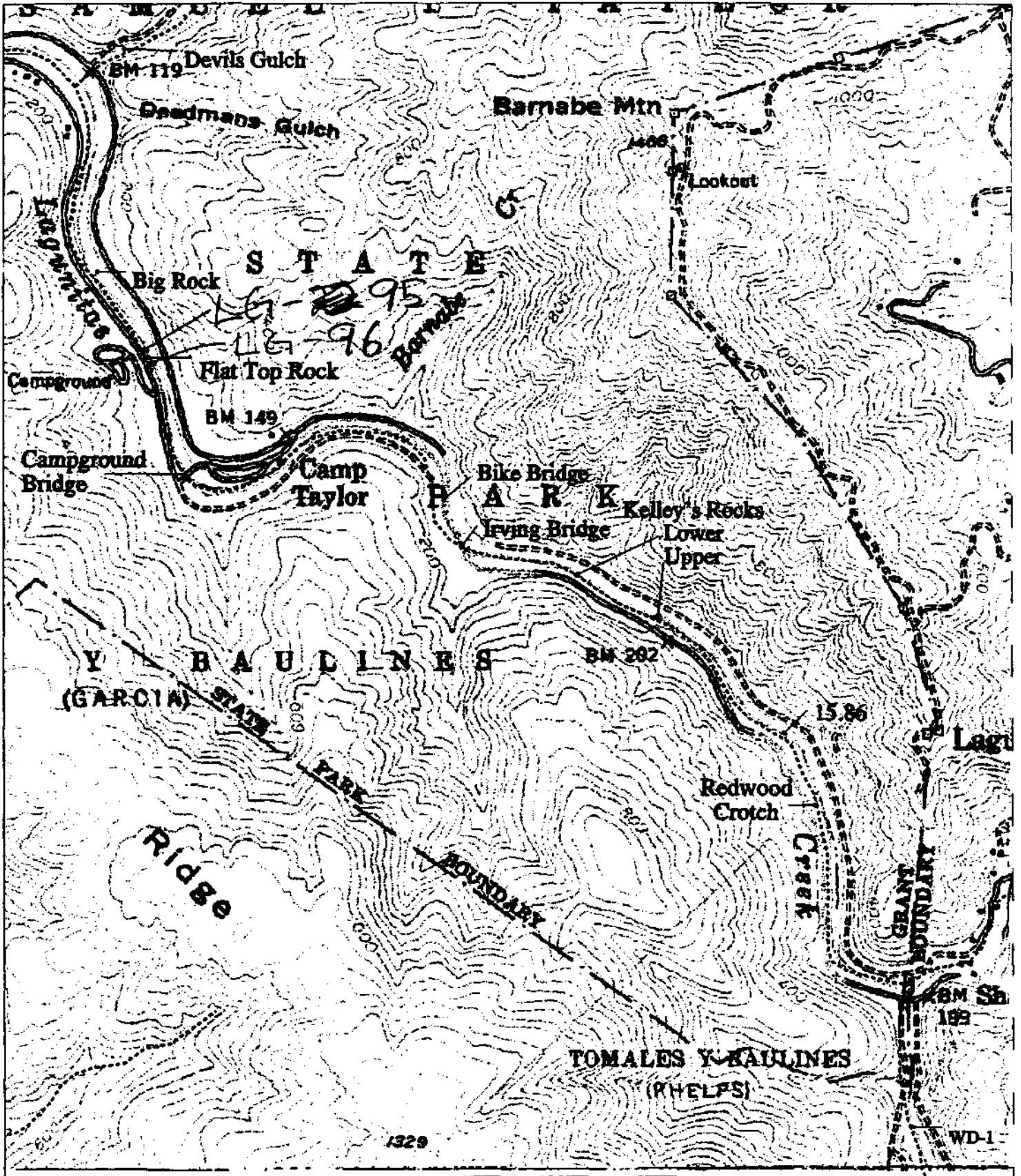


Scale: 1" = 0.25 miles
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Coho Spawner Survey Devil's Gulch to Peter's Dam

Date: 28-JAN-00

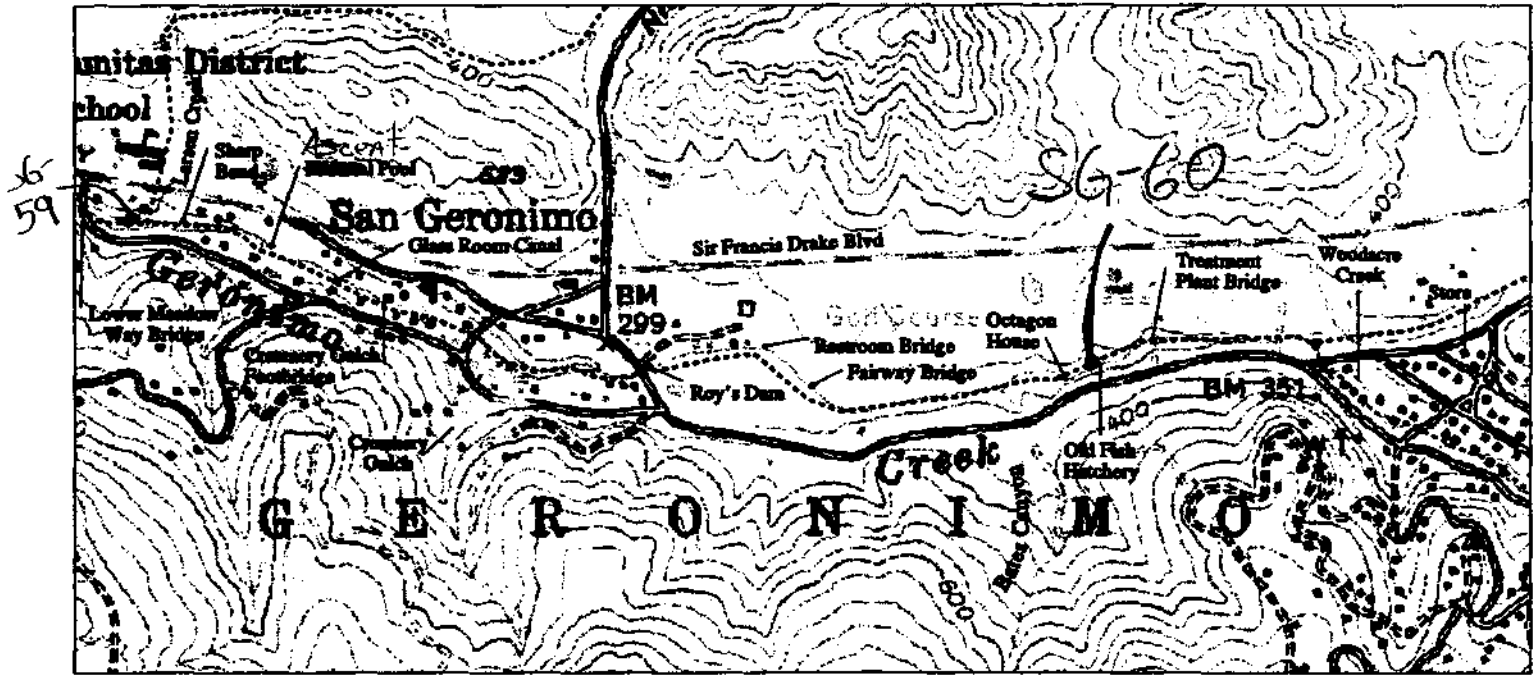
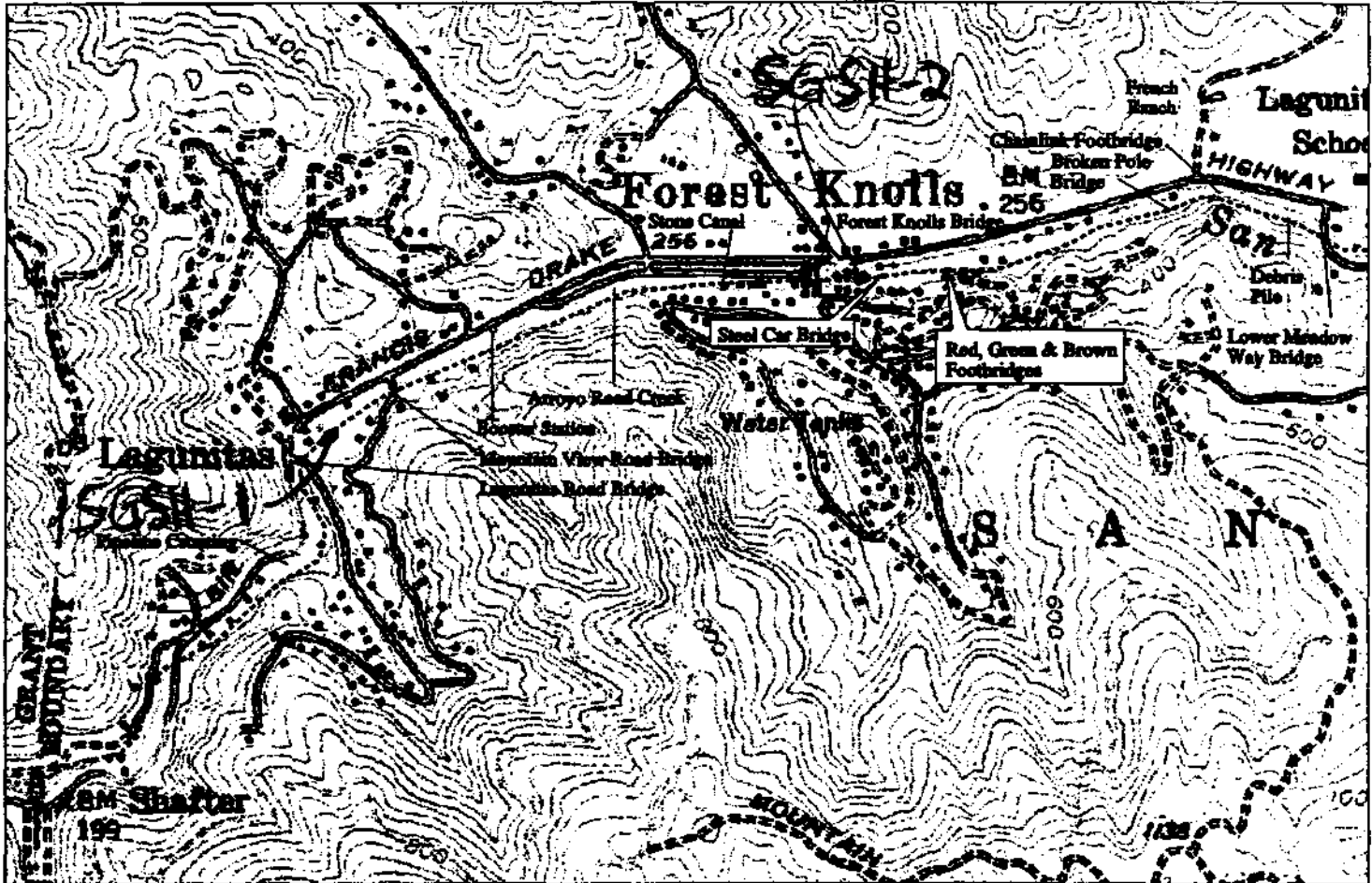


Scale: 1" = 0.25 miles
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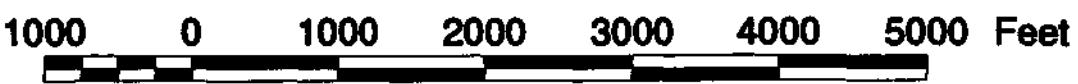


**Coho Spawner Survey
San Geronimo Creek**

Date: 1-FEB-00

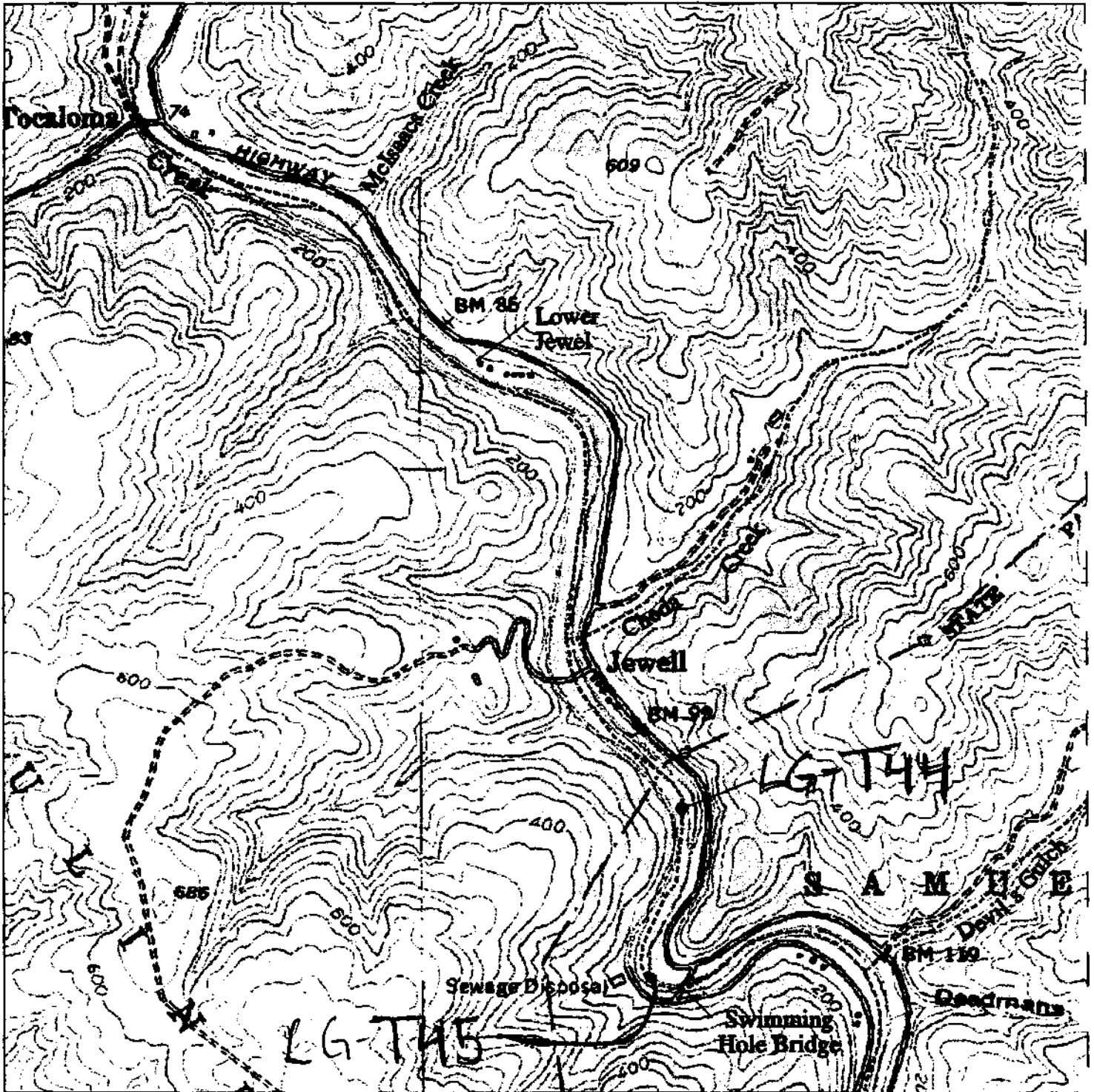


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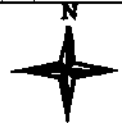


Coho Spawner Survey
Tocaloma to Devil's Gulch

Date: 2-FEB-00

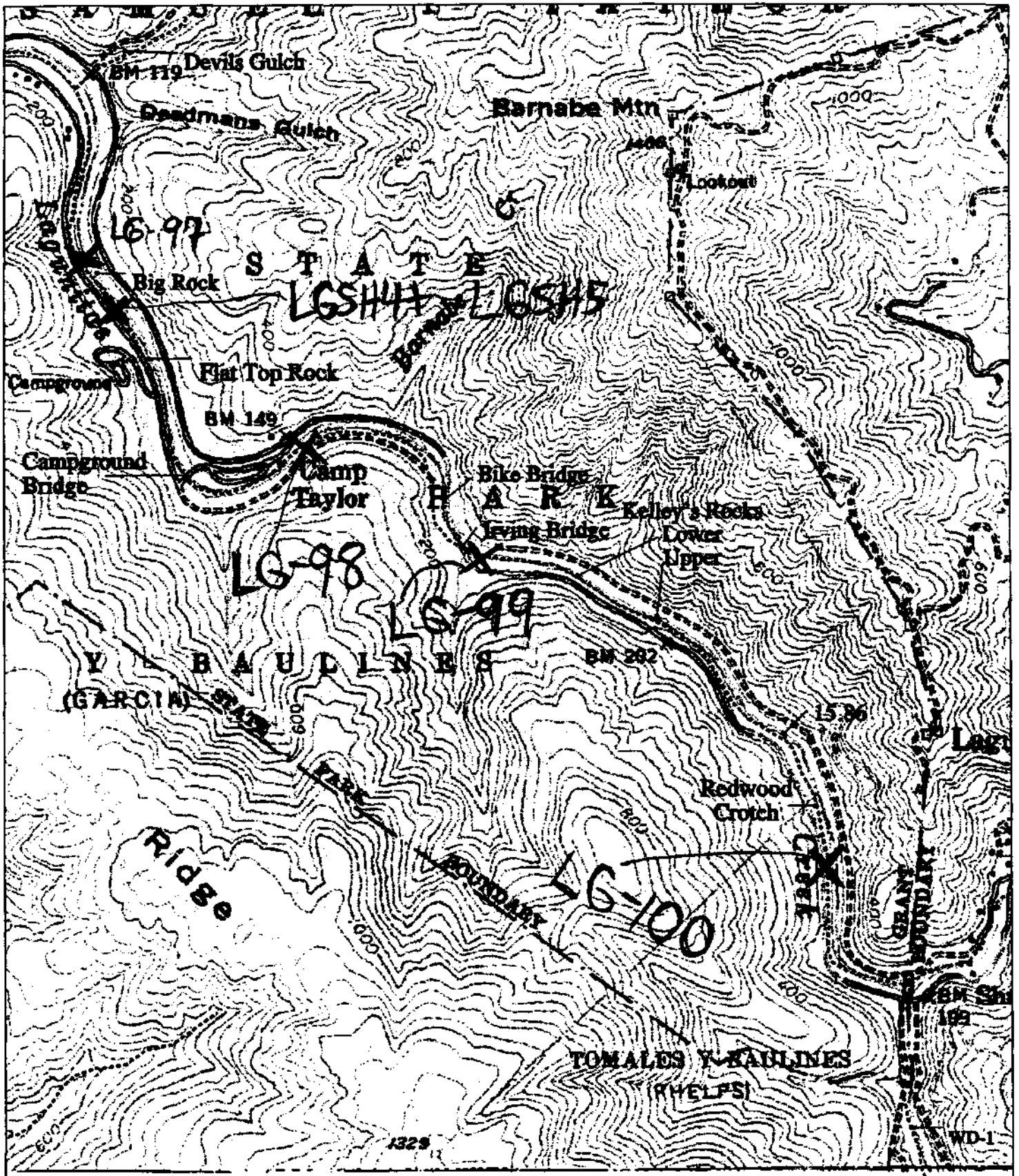


Scale: 1" = 0.25 miles
1000 0 1000 2000 3000 4000 5000 Feet



Coho Spawner Survey Devil's Gulch to Peter's Dam

Date: 2-FEB-00



Scale: 1" = 0.25 miles

1000 0 1000 2000 3000 4000 5000 Feet

