PUBLICATIONS RESULTING FROM STUDY

Bradford, D.F., C. Swanson, and M.S. Gordon. 1992. Effects of low pH and aluminum on two declining species of amphibians in the Sierra Nevada, California. J. Herpetol. 26: 369-377.

Jennings, W.B, D.F. Bradford, and D.F. Johnson. 1992. Dependence of the garter snake Thamnophis elegans on amphibians in the Sierra Nevada of California. J. Herpetol. 26: 503-505.

Bradford, D.F., M.S. Gordon, D.F. Johnson, R.D. Andrews, and W.B. Jennings. Acidic deposition as an unlikely cause for amphibian population declines in the Sierra Nevada, California. Manuscript in review.

GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

ANC	Acid Neutralizing Capacity
CARB	California Air Resources Board
EC	Electrical Conductivity
LC_{50}	Calculated concentration (pH) which is lethal to 50% of animals.
Critical pH	Highest pH at and below which an endpoint value is significantly reduced below that at pH 6.0 (no aluminum) (Freda 1986).
RSW	Reconstituted soft water

APPENDIX A

Location Maps for Survey Areas and Sample Sites

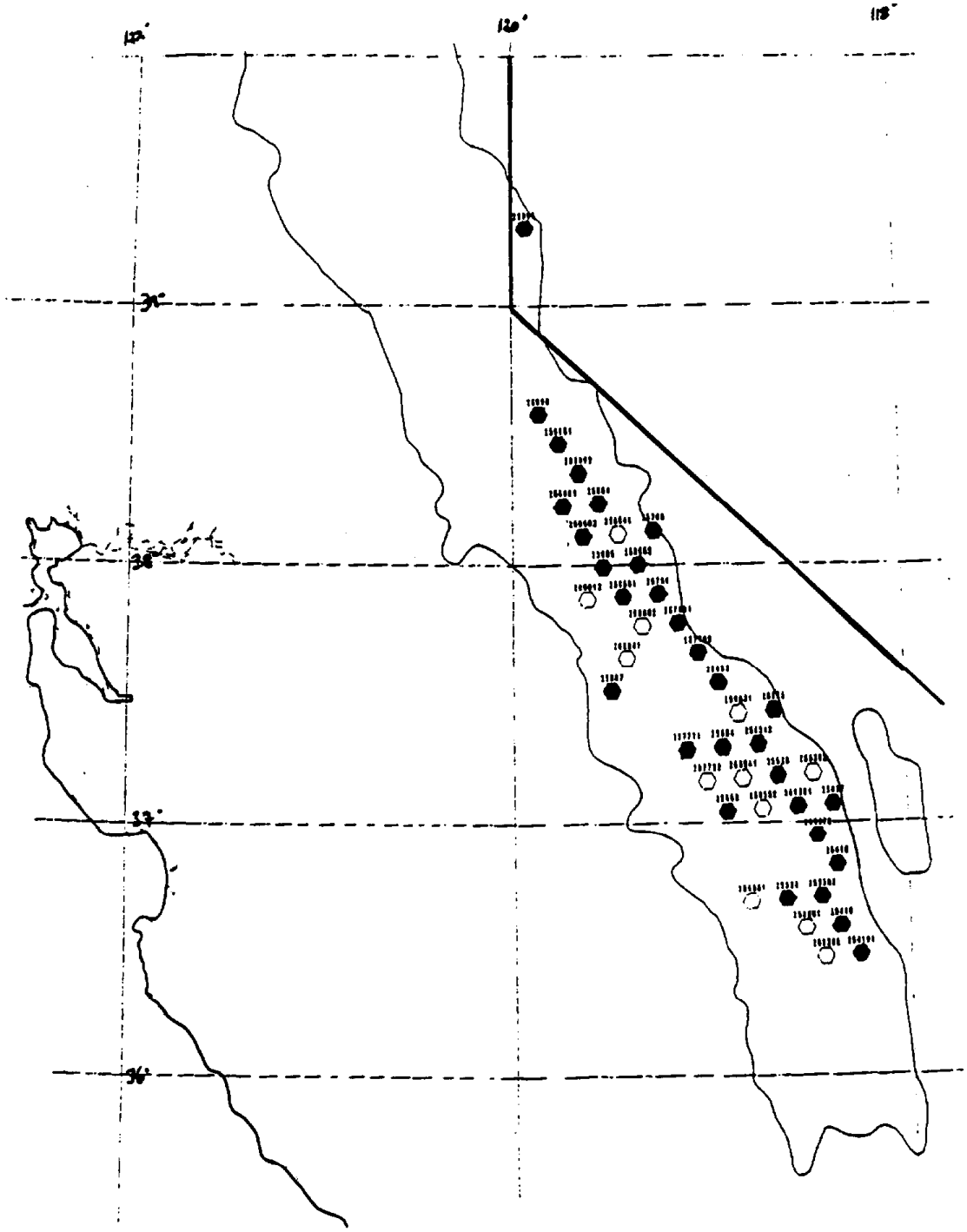
Coordinates for the center of each survey area, and the name of the 7 1/2′ quadrangle for the centerpoint, are provided in Table A-1. The location of all 30 survey areas is shown in Fig. A-1. Individual survey areas (15 km^2 circles) are shown on 7 1/2′ USGS quadrangles in most cases, although a few are represented on 15′ quadrangles. For survey areas shown on 7 1/2′ quadrangles, maps are reduced in size for presentation. Dark lines on the maps indicate the 2,440 m (8,000 foot) level, below which was excluded from the survey.

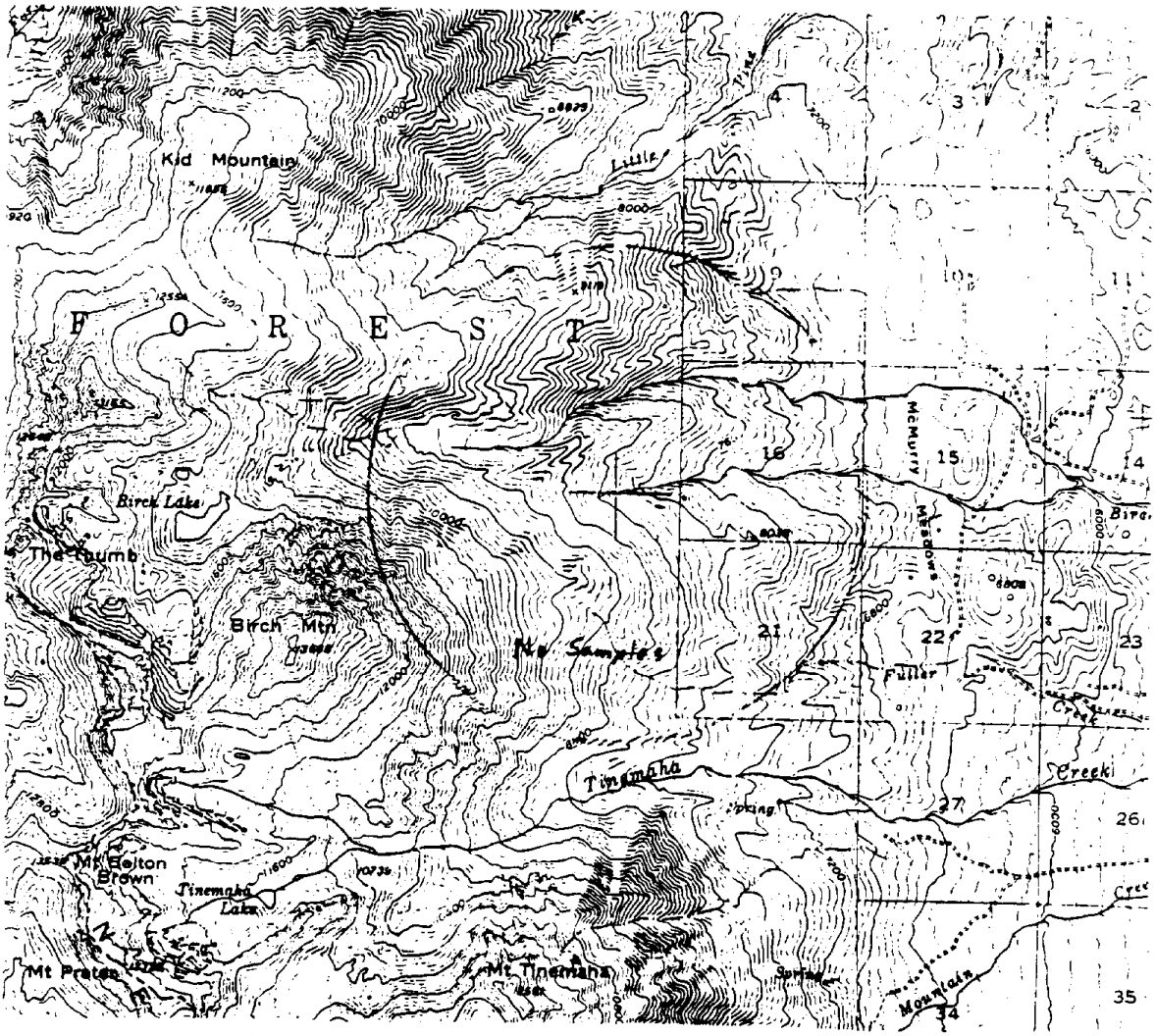
Table A-1. Centerpoint coordinates of survey areas as selected by EPA's Environmental Monitoring and Assessment Program (EMAP).

EMAP hexagon center-points approximately 8,000 ft. or above in the Sierra Nevada. Each 40 sq. km. hexagon includes one or more lakes as identified by National Lake Survey data. Longitude and latitude are in degrees, minutes, seconds. Maps refer to the center-point only. Data compiled by Colleen Burch Johnson for John Stoddard 5/8/90.

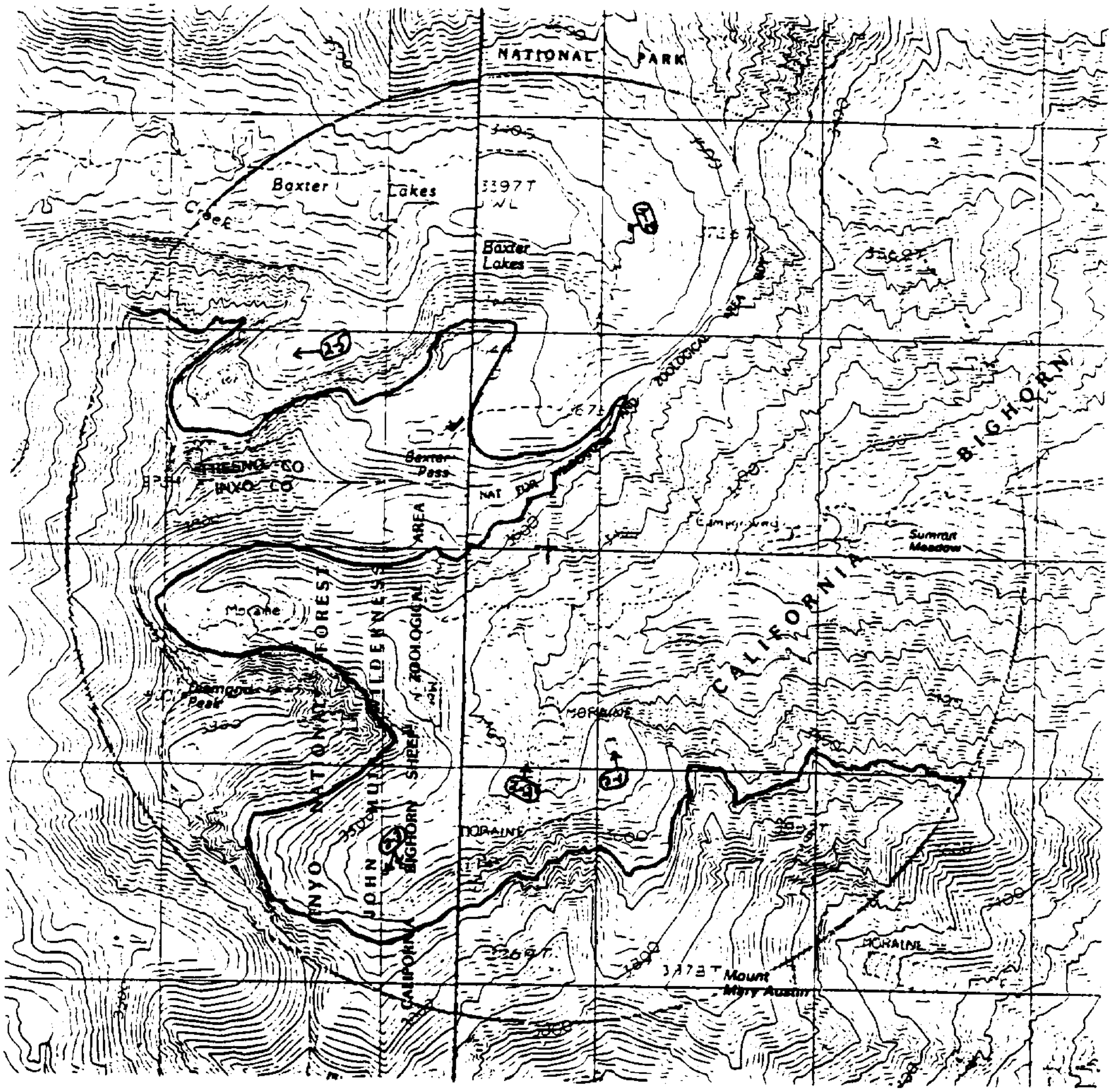
Survey Area No.	HEXAGON #	LONGITUDE	LATITUDE	1:250,000 MAP	7.5' MAP
1	25417	-118 23 08.26	37 04 37.68	Mariposa	Split Mountain
2	25418	-118 22 15.36	36 49 58.54	Fresno	Kearsarge Peak
3	25419	-118 21 23.76	36 35 19.24	Fresno	Mount Whitney
4	254191	-118 15 38.95	36 28 15.16	Fresno	Johnson Peak
5	25535	-118 40 41.03	37 25 46.14	Mariposa	Mount Morgan
6	25536	-118 39 42.98	37 11 07.62	Mariposa	Mount Darwin
7	255361	-118 33 52.41	37 04 05.03	Mariposa	North Palisade
8	255372	-118 28 03.20	36 57 02.00	Fresno	Mount Pinchot
9	25538	-118 37 50.90	36 41 50.06	Fresno	Mount Silliman
10	255382	-118 27 09.91	36 42 22.89	Fresno	Mount Brewer
11	25653	-118 57 23.03	37 32 12.82	Mariposa	Bloody Mtn.
12	25654	-118 56 21.09	37 17 34.75	Mariposa	Florence Lake
13	256542	-118 45 34.93	37 18 09.78	Mariposa	Mount Hilgard
14	25655	-118 55 20.55	37 02 56.52	Mariposa	Courtright Res.
15	25768	-119 16 24.50	38 07 51.30	Walker Lake	Twin Lakes
16	25769	-119 15 15.75	37 53 14.06	Mariposa	Tioga Pass
17	257691	-119 09 16.75	37 46 14.09	Mariposa	Koip Peak
18	257702	-119 03 19.18	37 39 13.67	Mariposa	Mammoth Mtn.
19	257711	-119 07 07.19	37 16 58.65	Mariposa	Mount Givens
20	25884	-119 33 21.37	38 14 11.30	Walker Lake	Tower Peak
21	25885	-119 32 08.59	37 59 34.55	Mariposa	Ten Lakes
22	258851	-119 26 07.12	37 52 35.70	Mariposa	Falls Ridge
23	258852	-119 21 16.18	38 00 13.59	Walker Lake	Dunderberg Pk.
24	25887	-119 29 47.52	37 30 20.51	Mariposa	Sing Peak
25	25995	-119 55 44.91	39 18 51.63	Reno	Mount Rose, NV
26	25998	-119 51 40.14	38 35 04.46	Walker Lake	Ebbetts Pass
27	259981	-119 45 32.41	38 28 07.20	Walker Lake	Dardanelles Cn
28	259991	-119 44 15.89	38 13 30.90	Walker Lake	Emigrant Lake
29	259992	-119 39 26.15	38 21 09.48	Walker Lake	Sonora Pass
30	260002	-119 38 11.51	38 06 32.95	Walker Lake	Tiltill Mtn.

Figure A-1. Location of the EMAP hexagons (40 km^2) in the Sierra Nevada with centerpoint above 2,440 m elevation (8,000 feet) and containing at least one lake, ≥ 1 ha in area. The number of hexagons excluded because a lake was lacking was negligible (J. Stoddard, pers. comm.). Shaded hexagons represent the 30 randomly selected for survey (Table A-1).

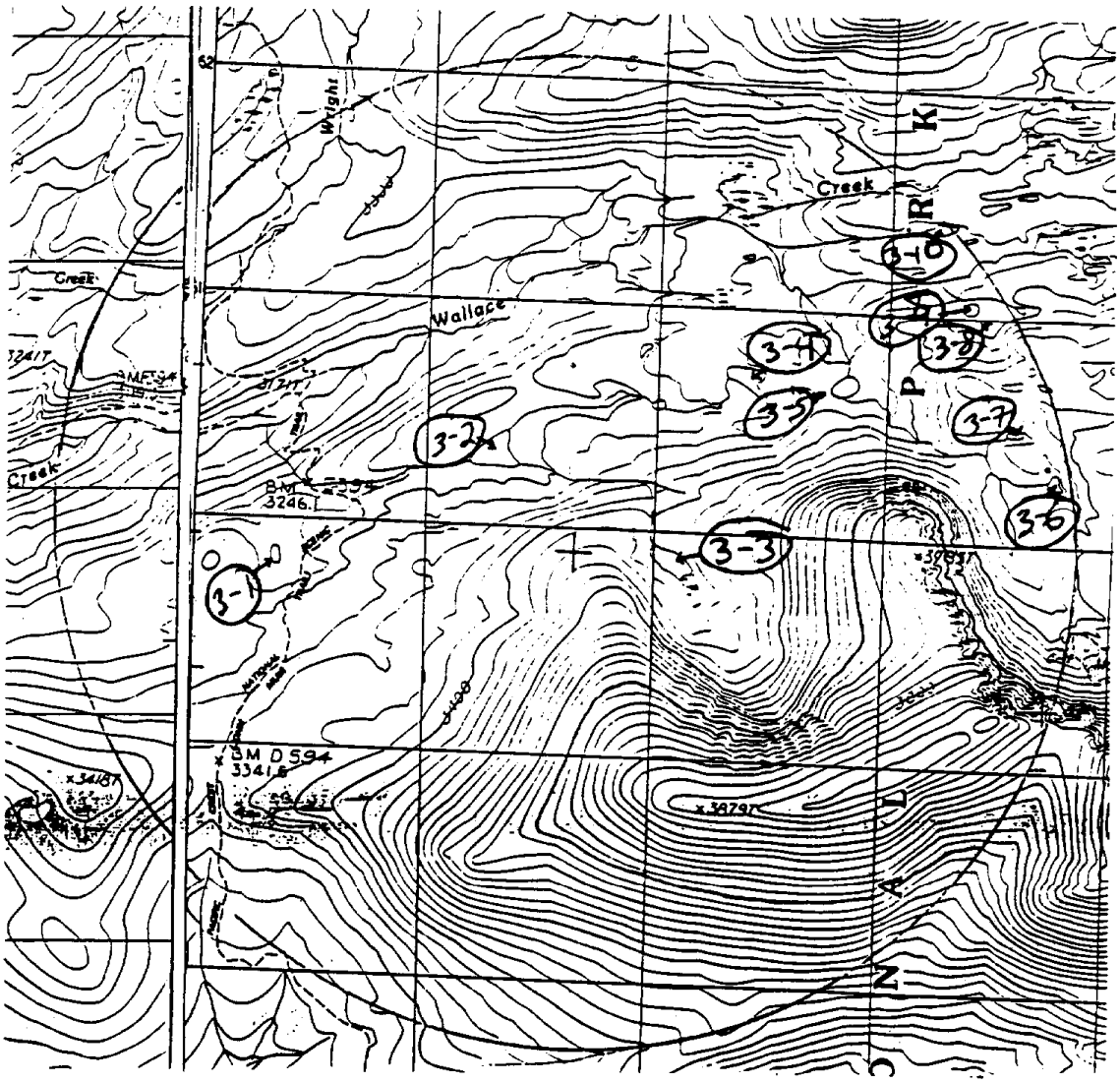




Survey Area No. 1 (15' Quadrangle)



Survey Area No. 2 (7 1/2' Quadrangle)



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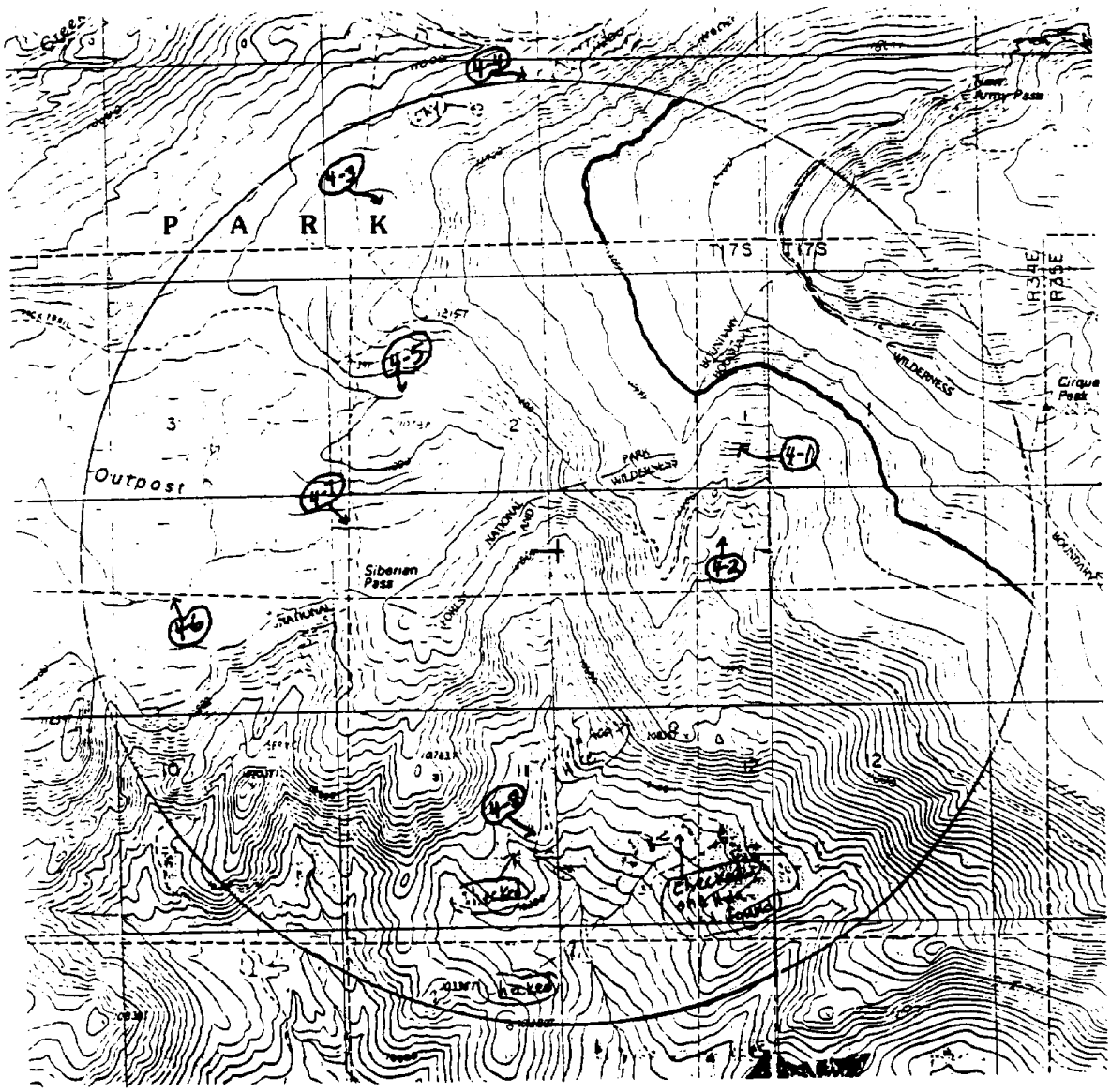

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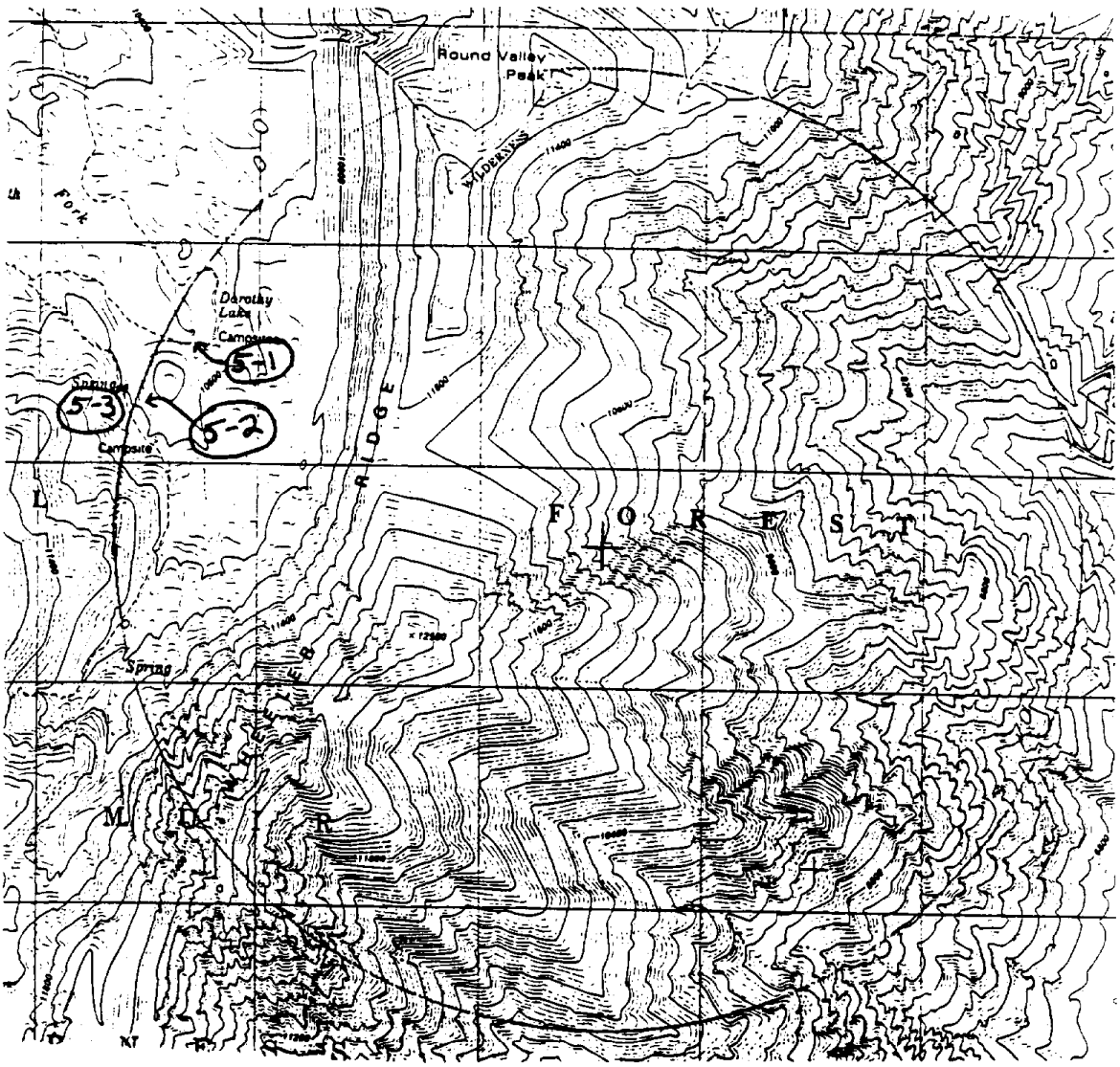

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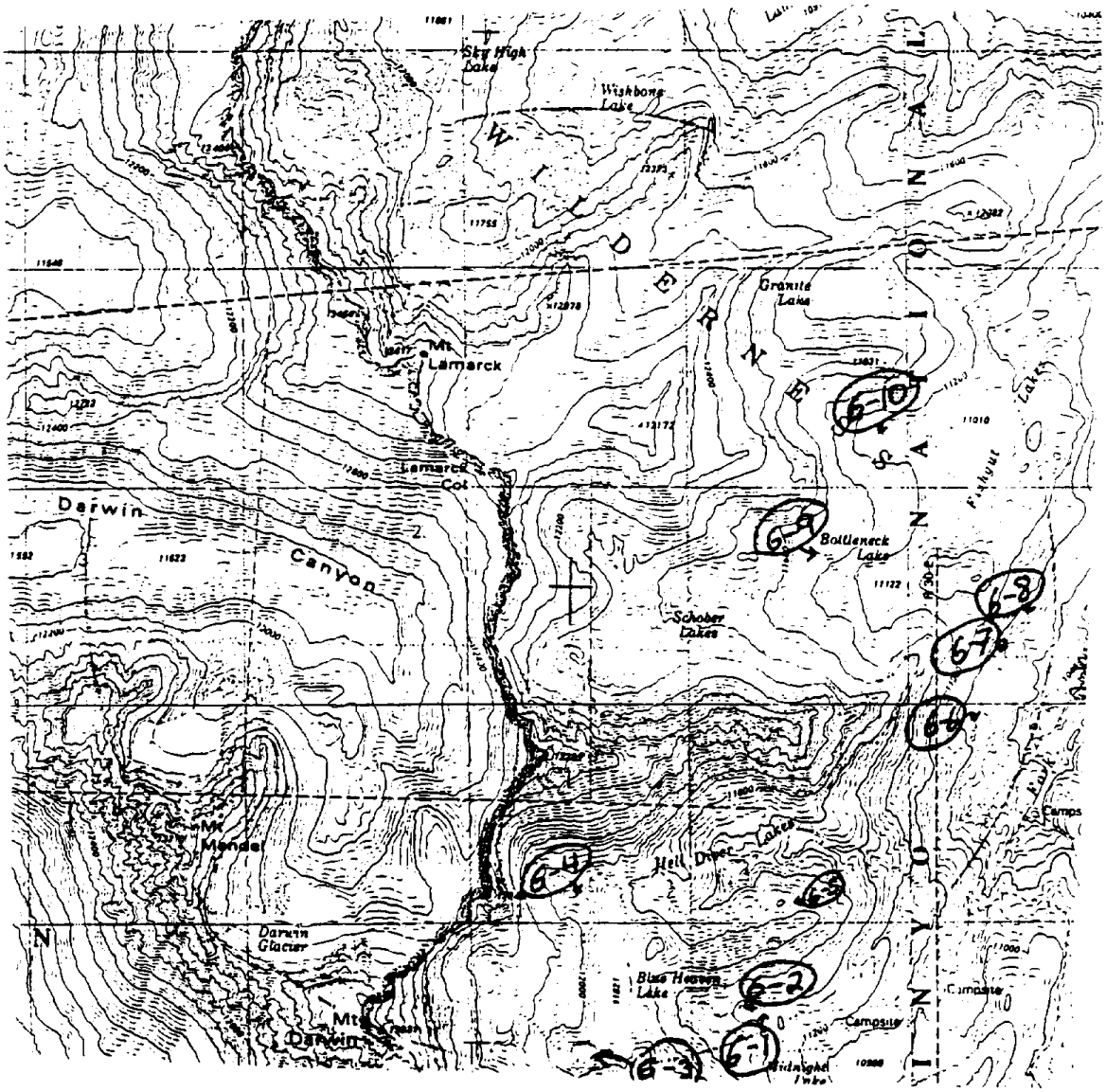

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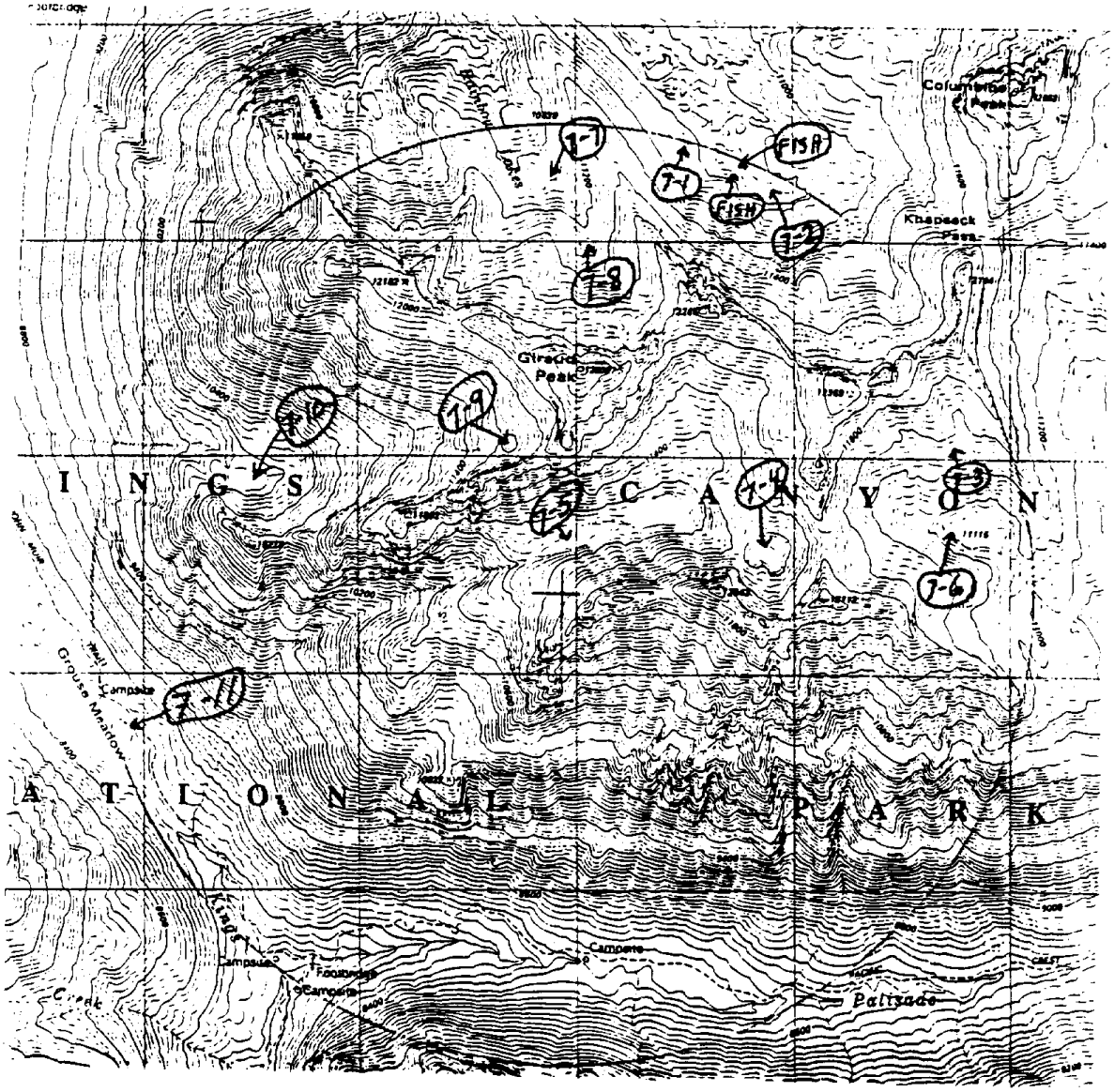

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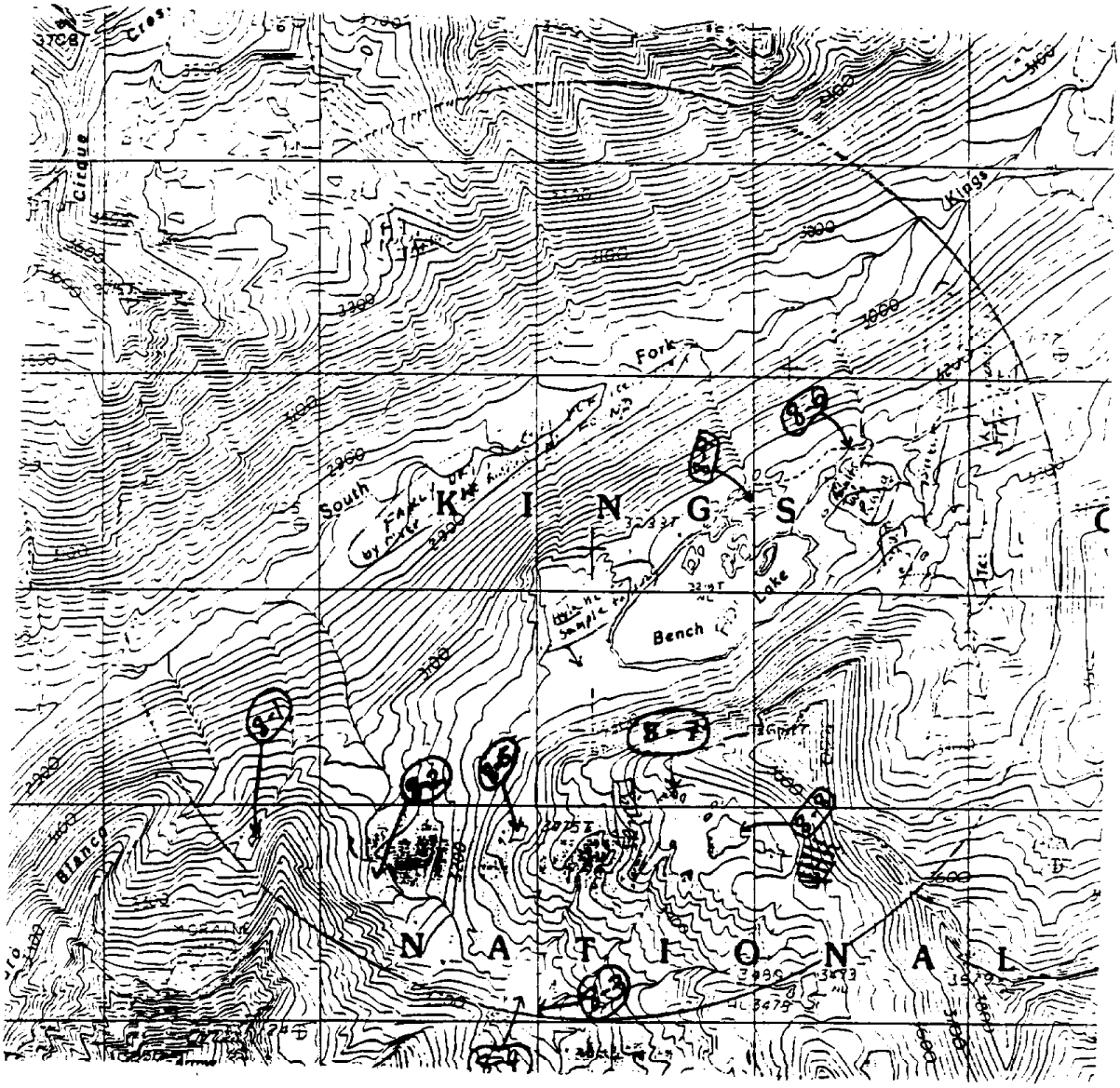

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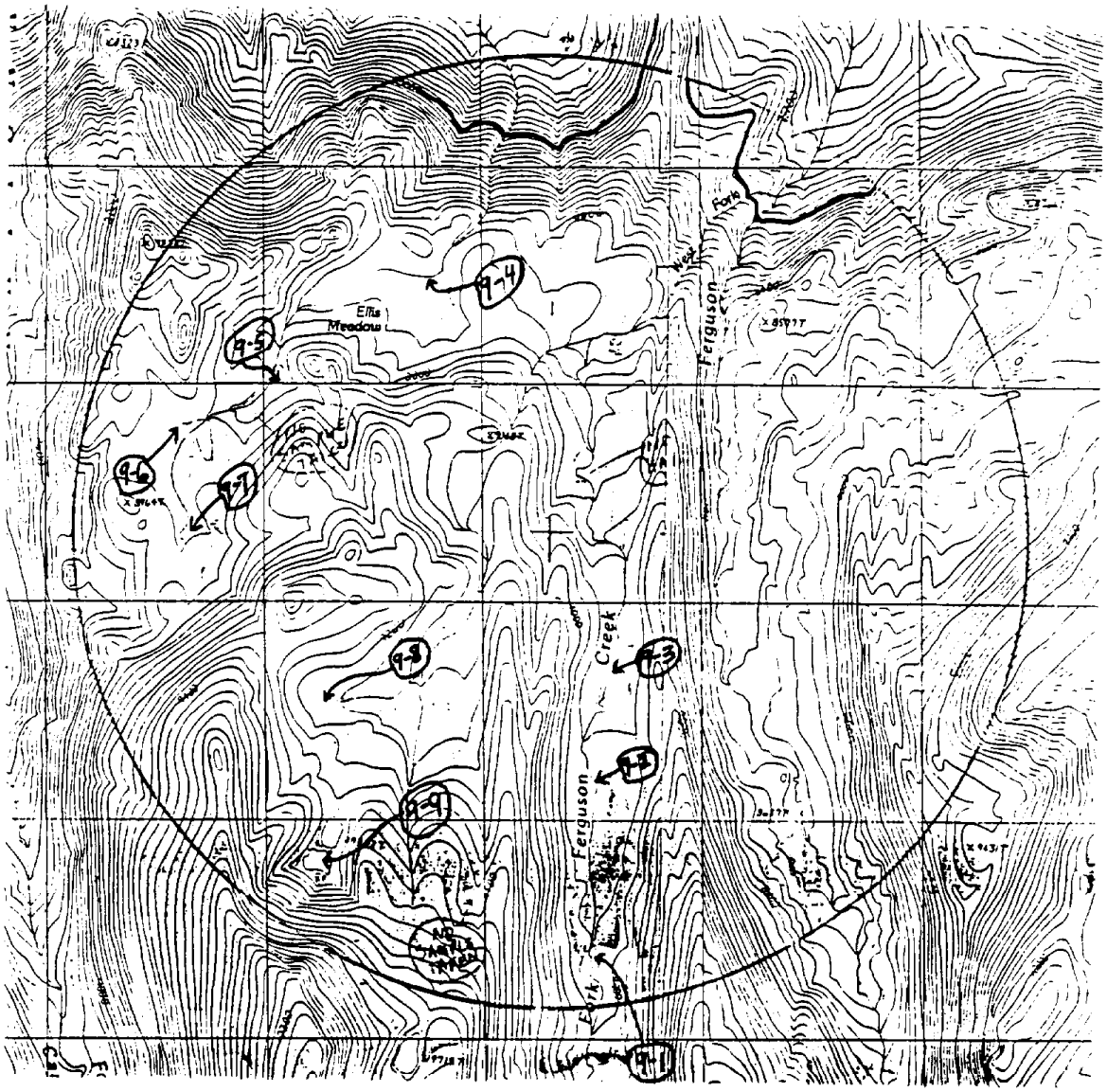

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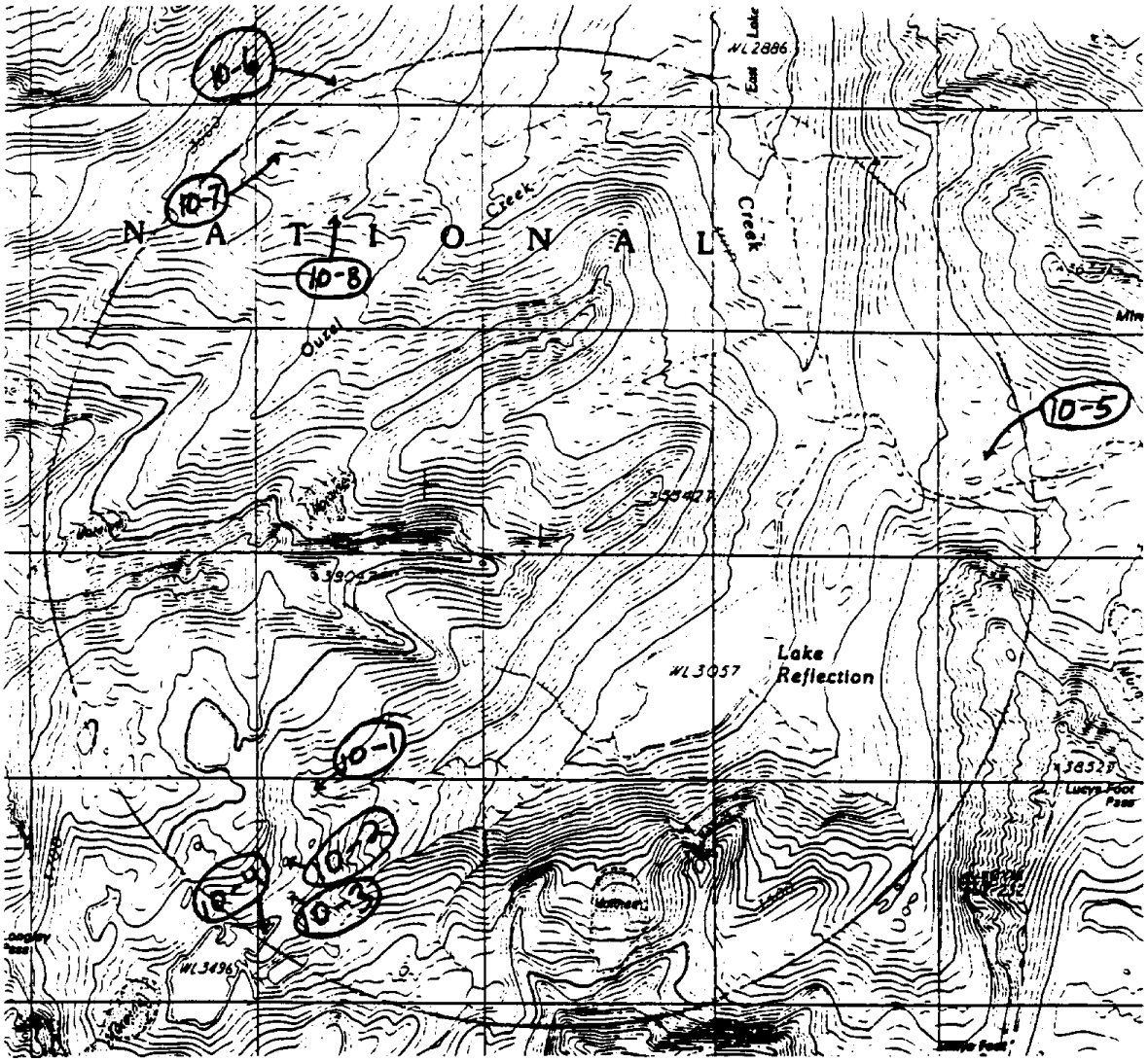

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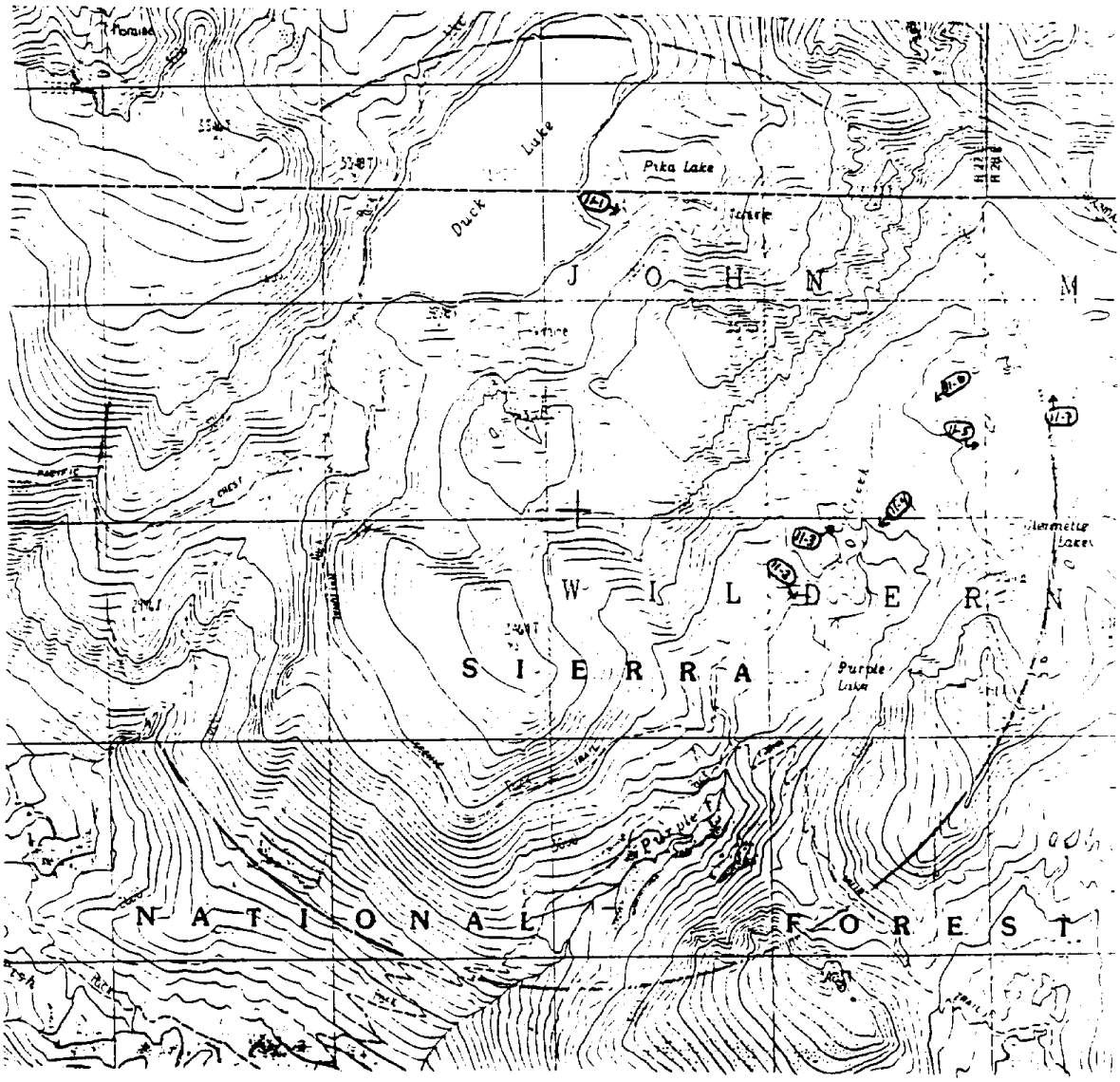

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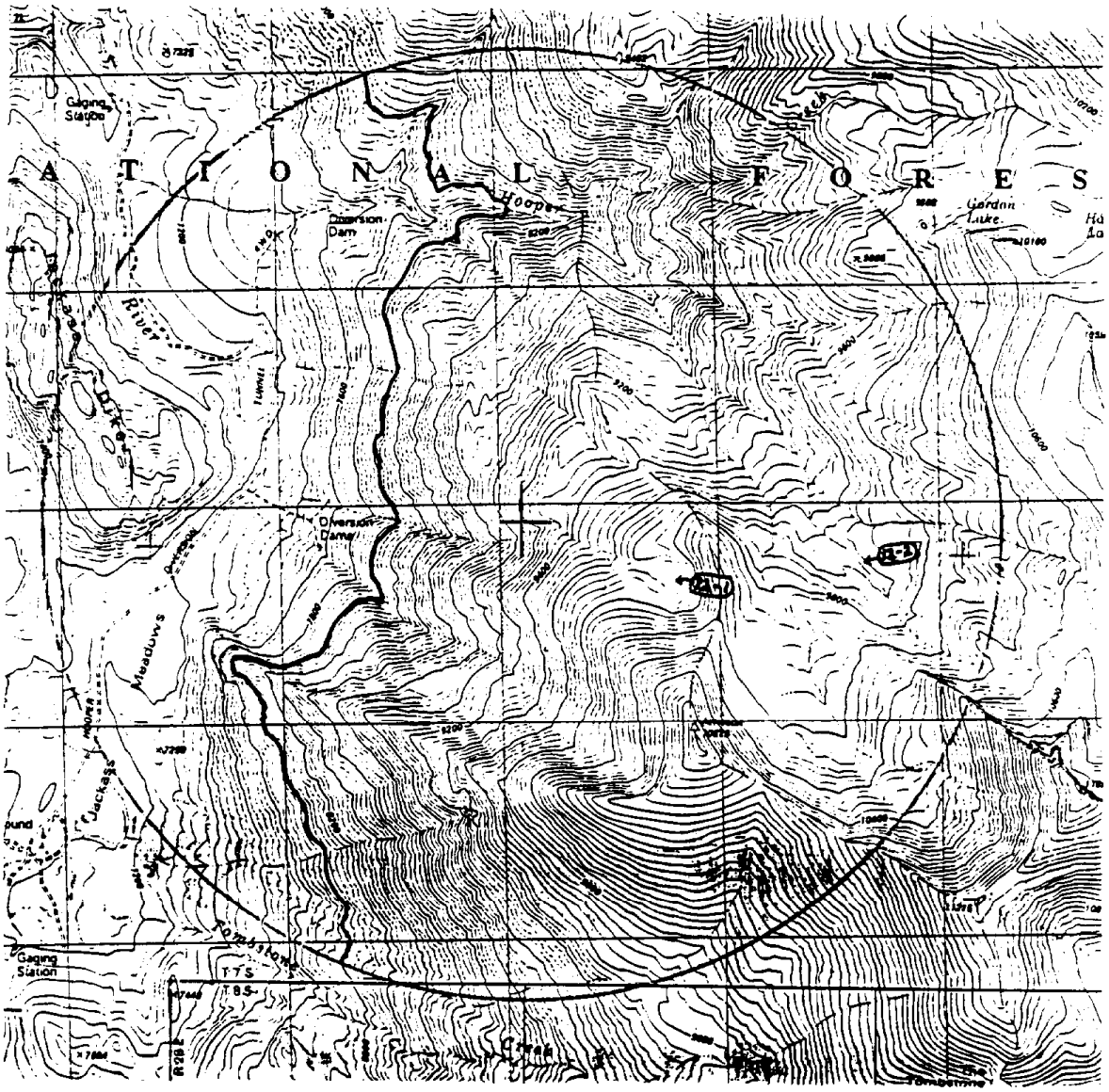
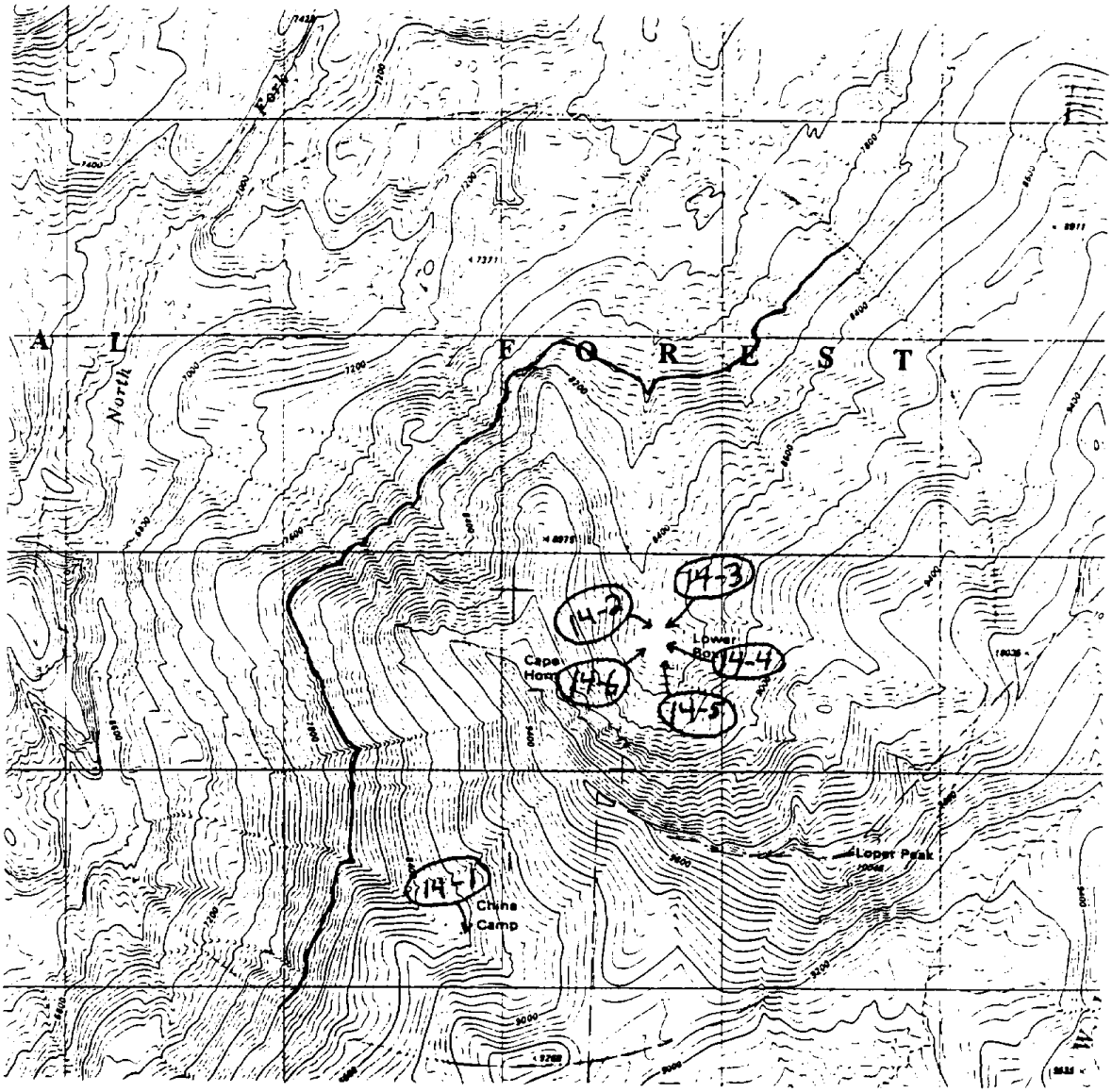


Survey Area No. 12 (7 1/2' Quadrangle)

Survey Area No. 13 (7 1/2' Quadrangle)



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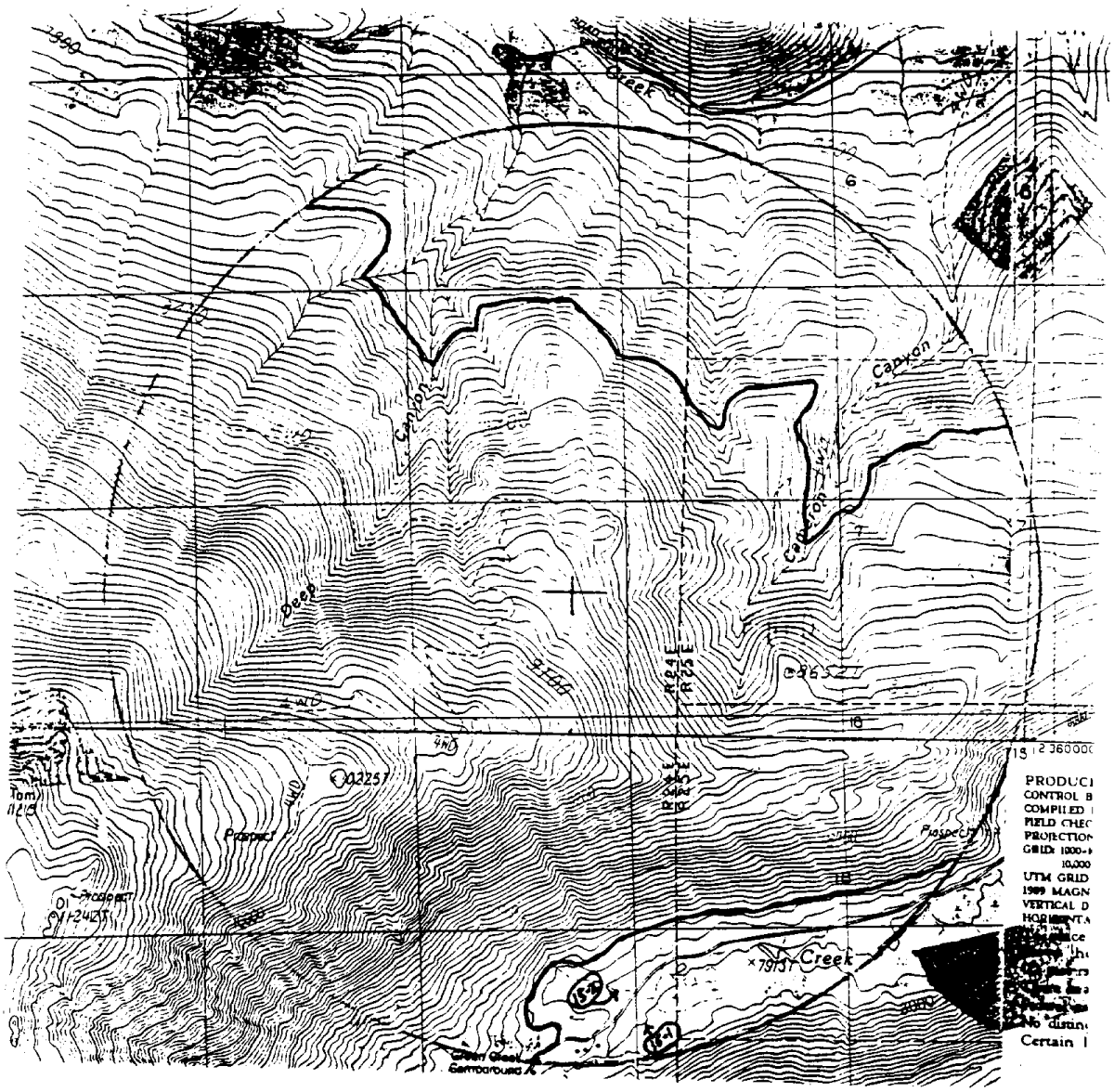
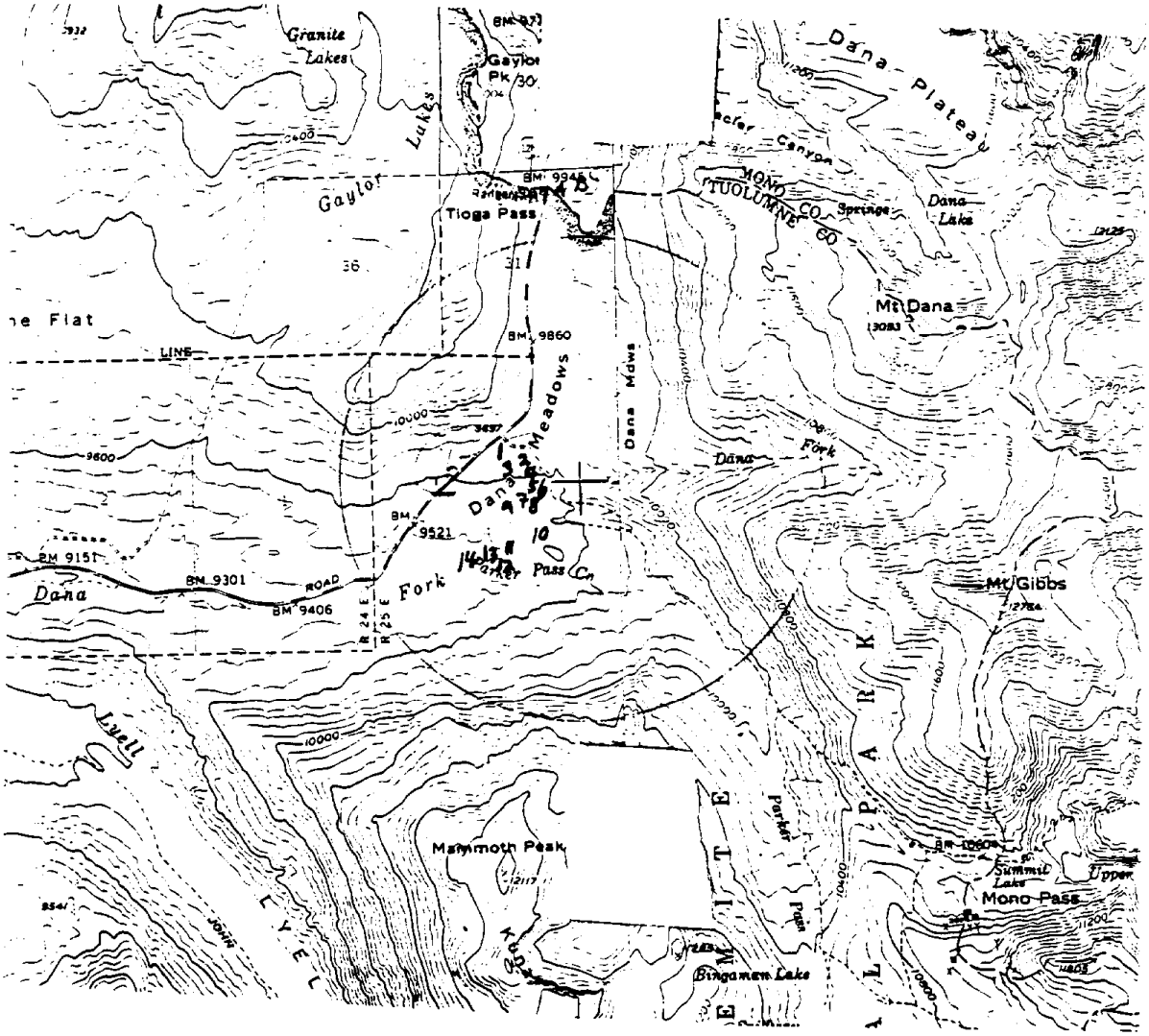
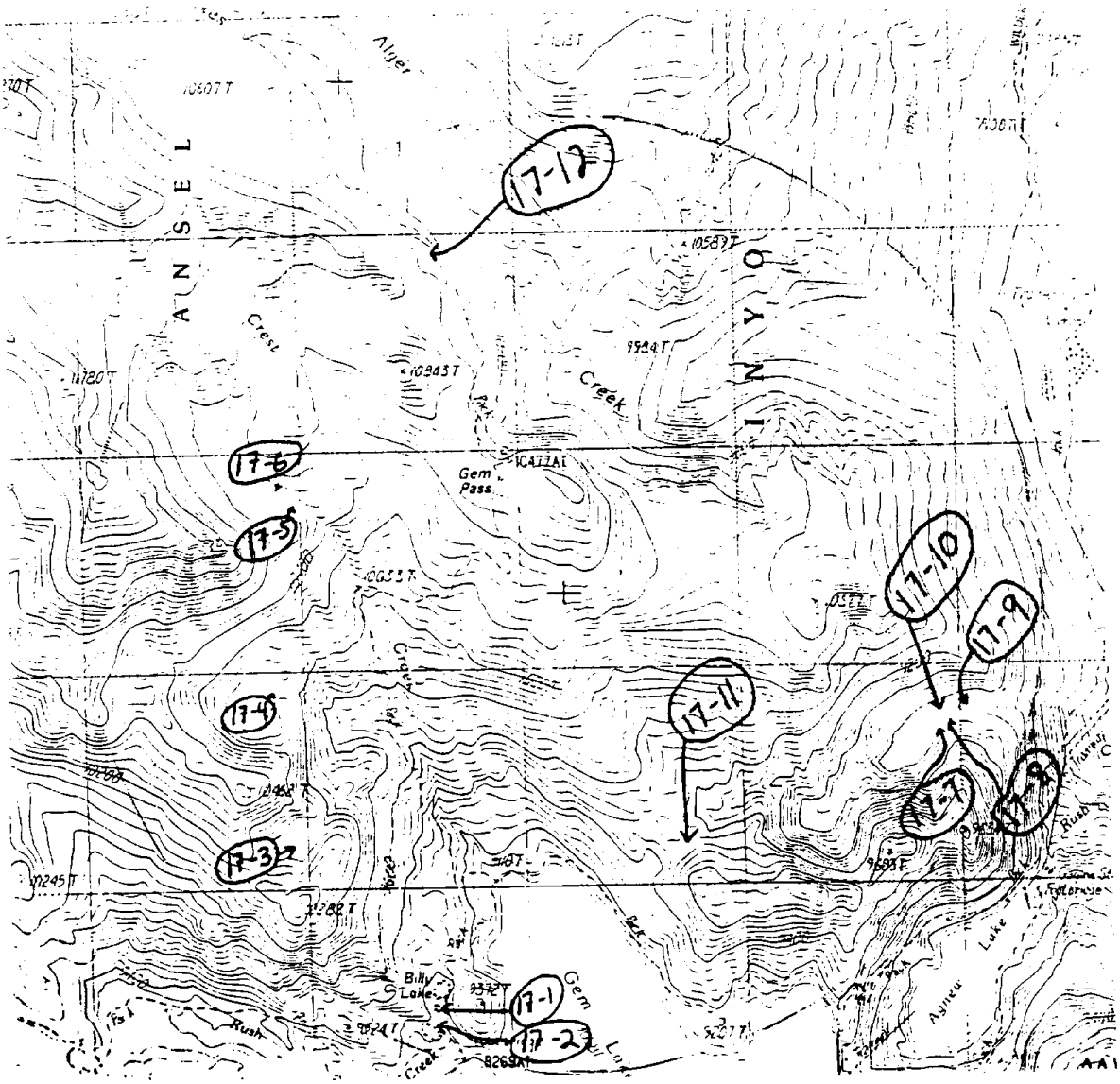


Survey Area No. 15 (7 1/2' Quadrangle)

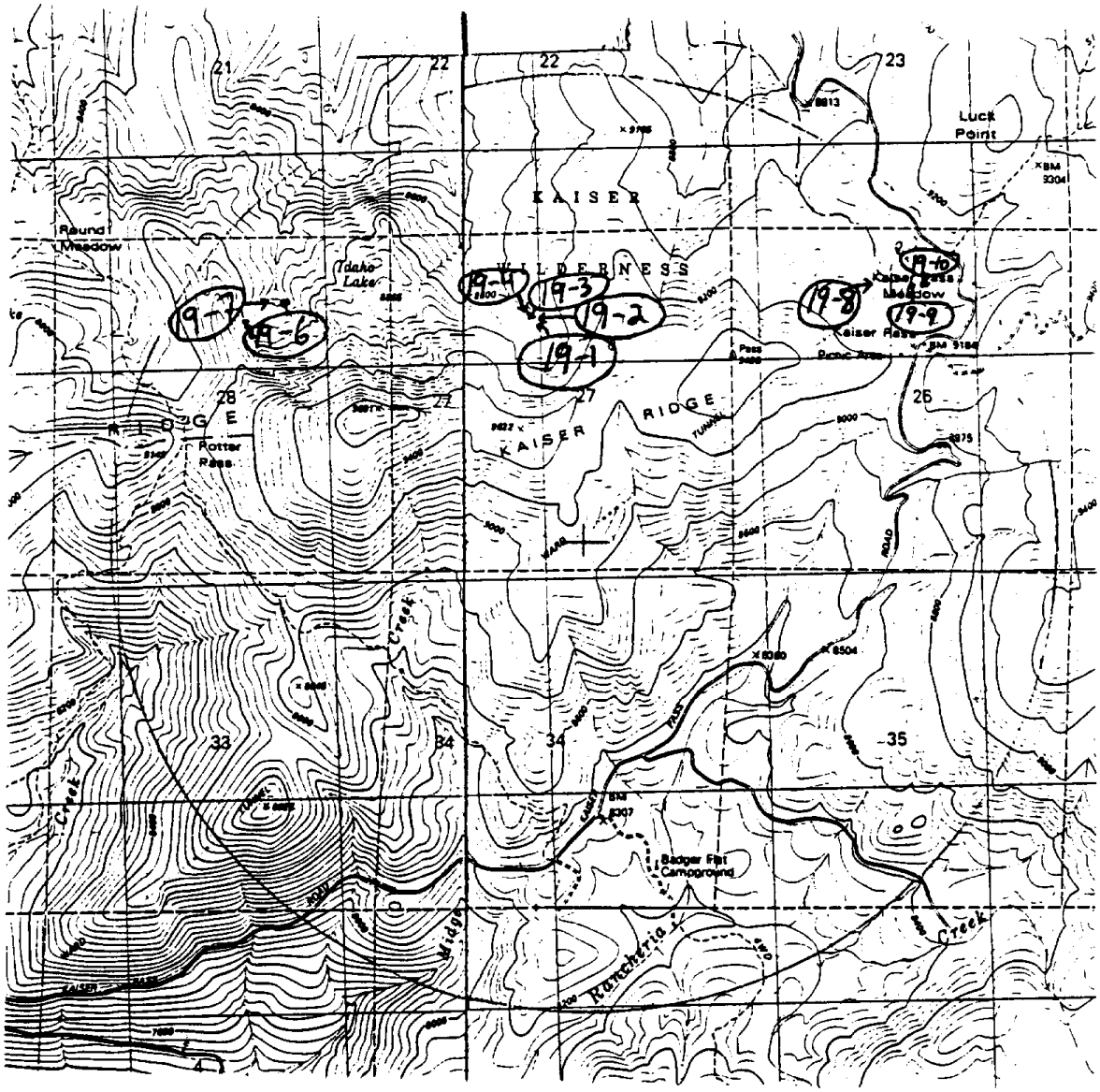


Survey Area No. 16 (15' Quadrangle)

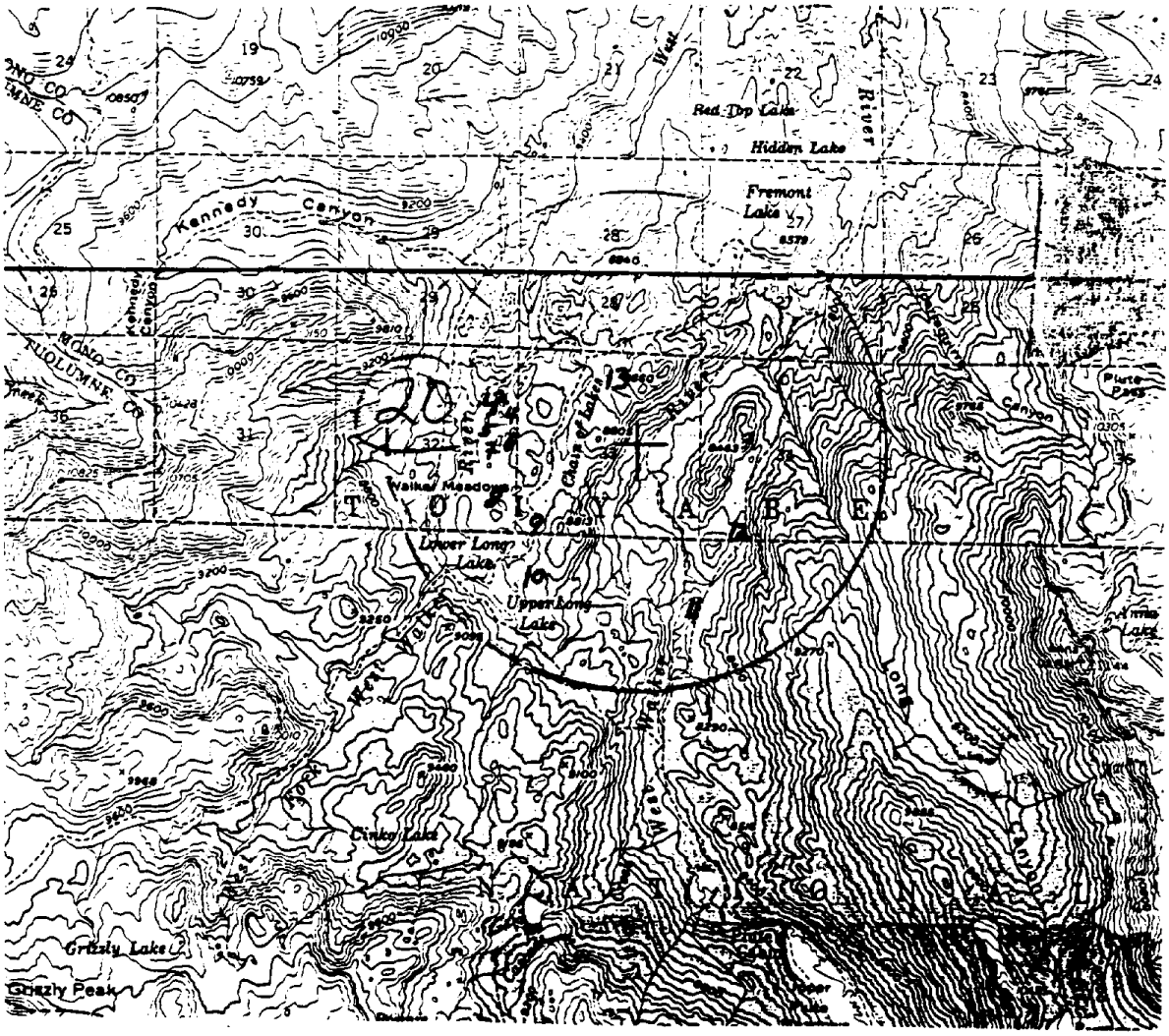


Survey Area No. 17 (7 1/2' Quadrangle)

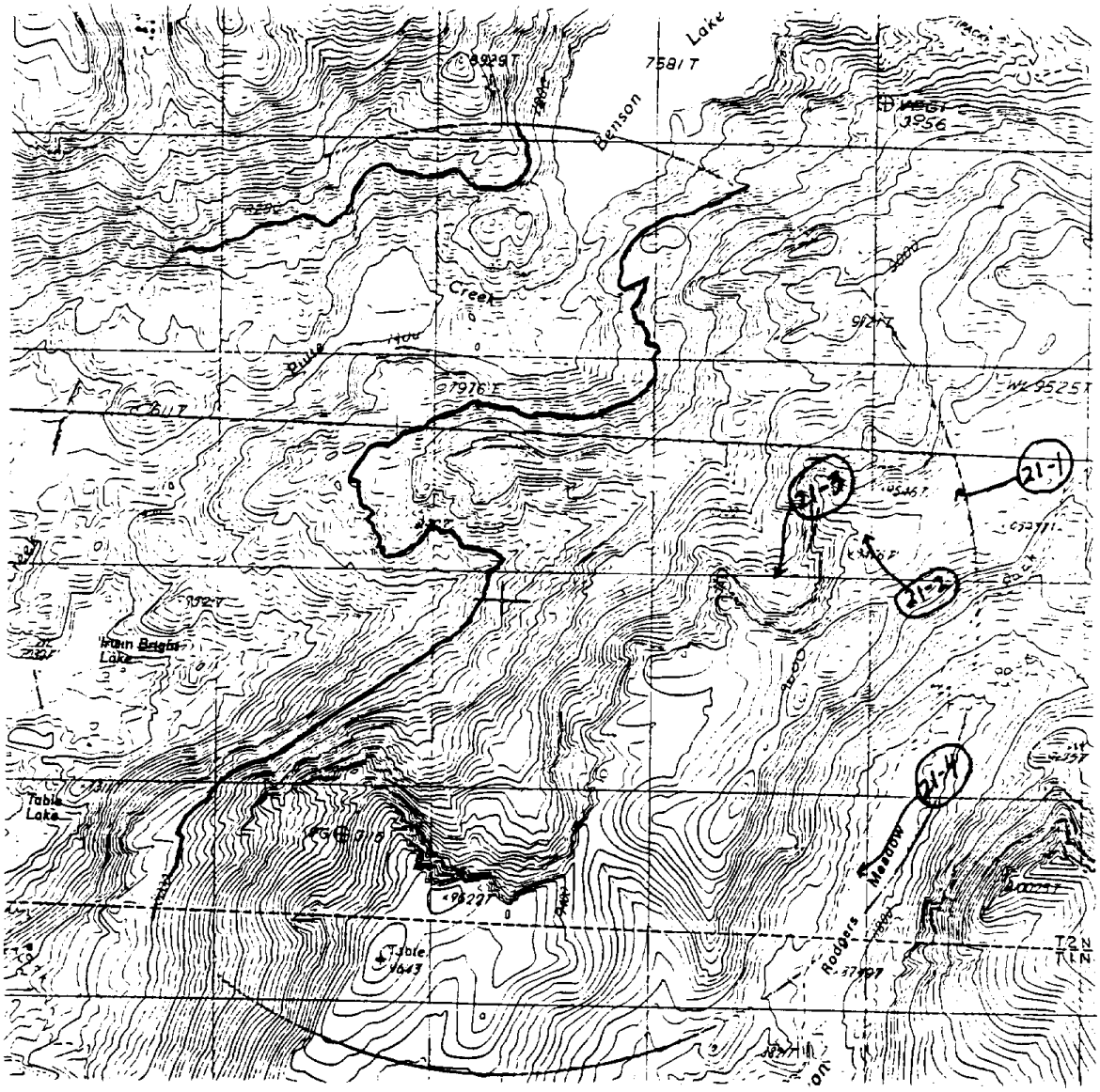
Survey Area No. 18 (7 1/2′ Quadrangle)



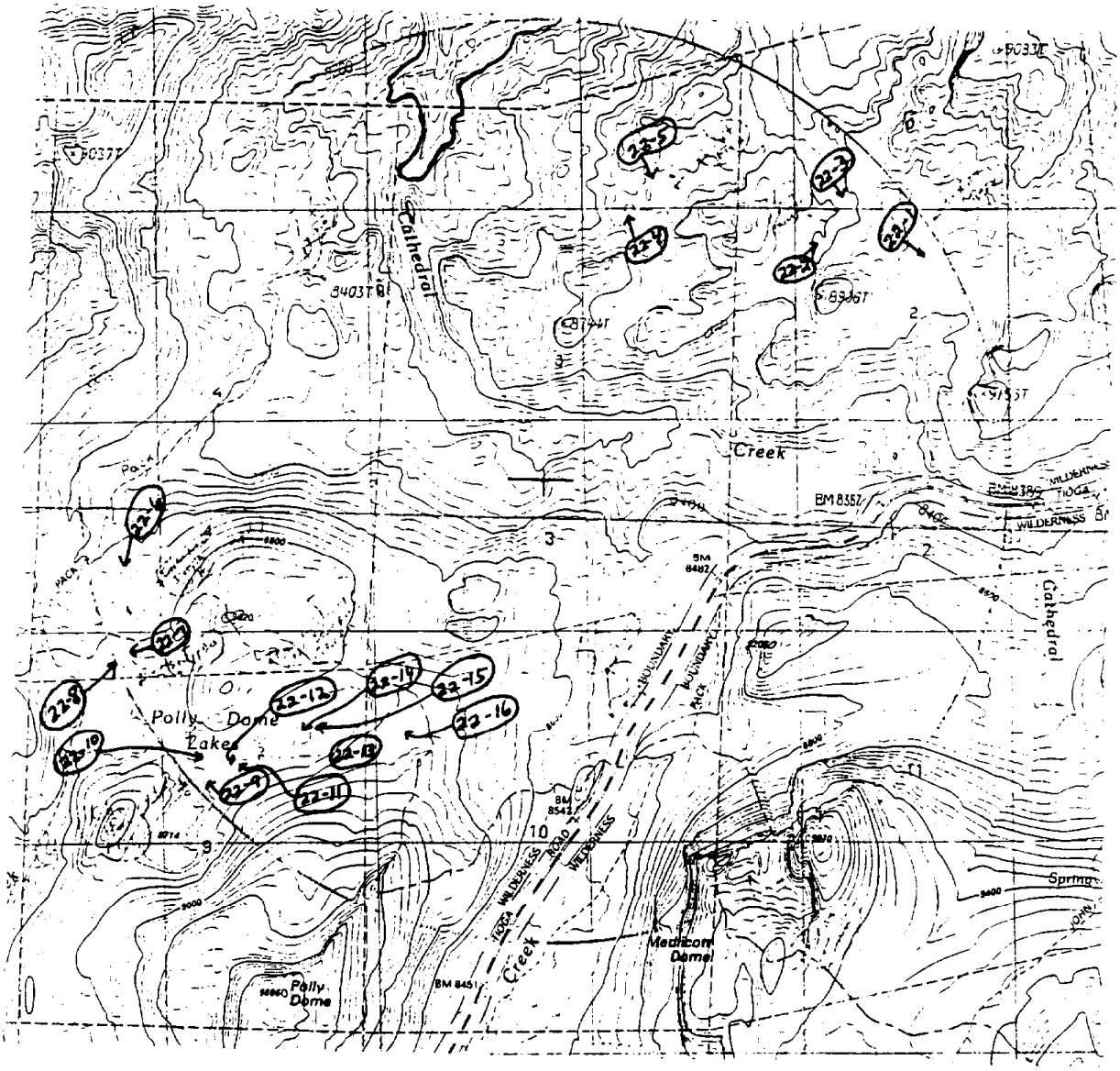
Survey Area No. 19 (7 1/2' Quadrangle)



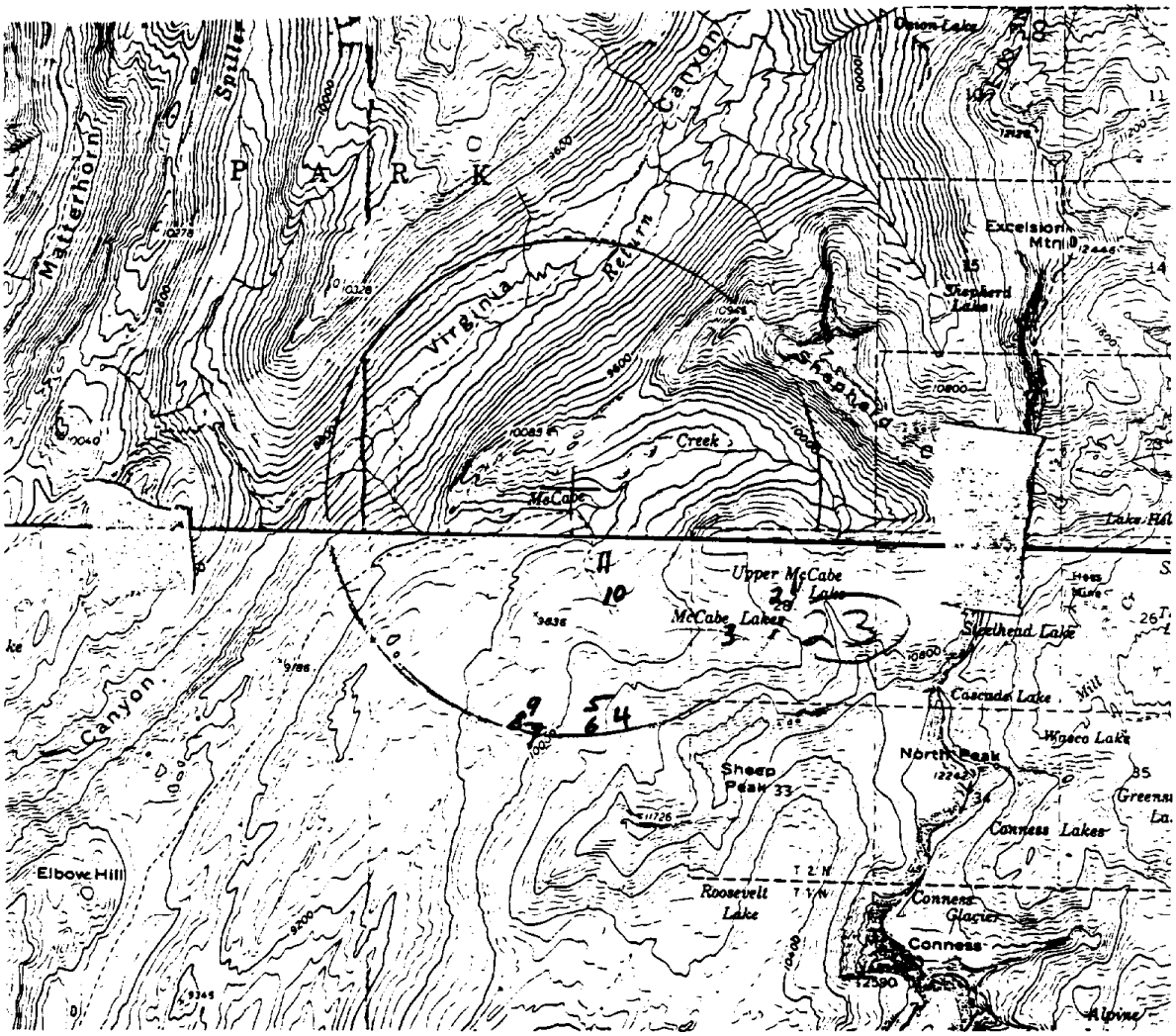
Survey Area No. 20 (15' Quadrangle)



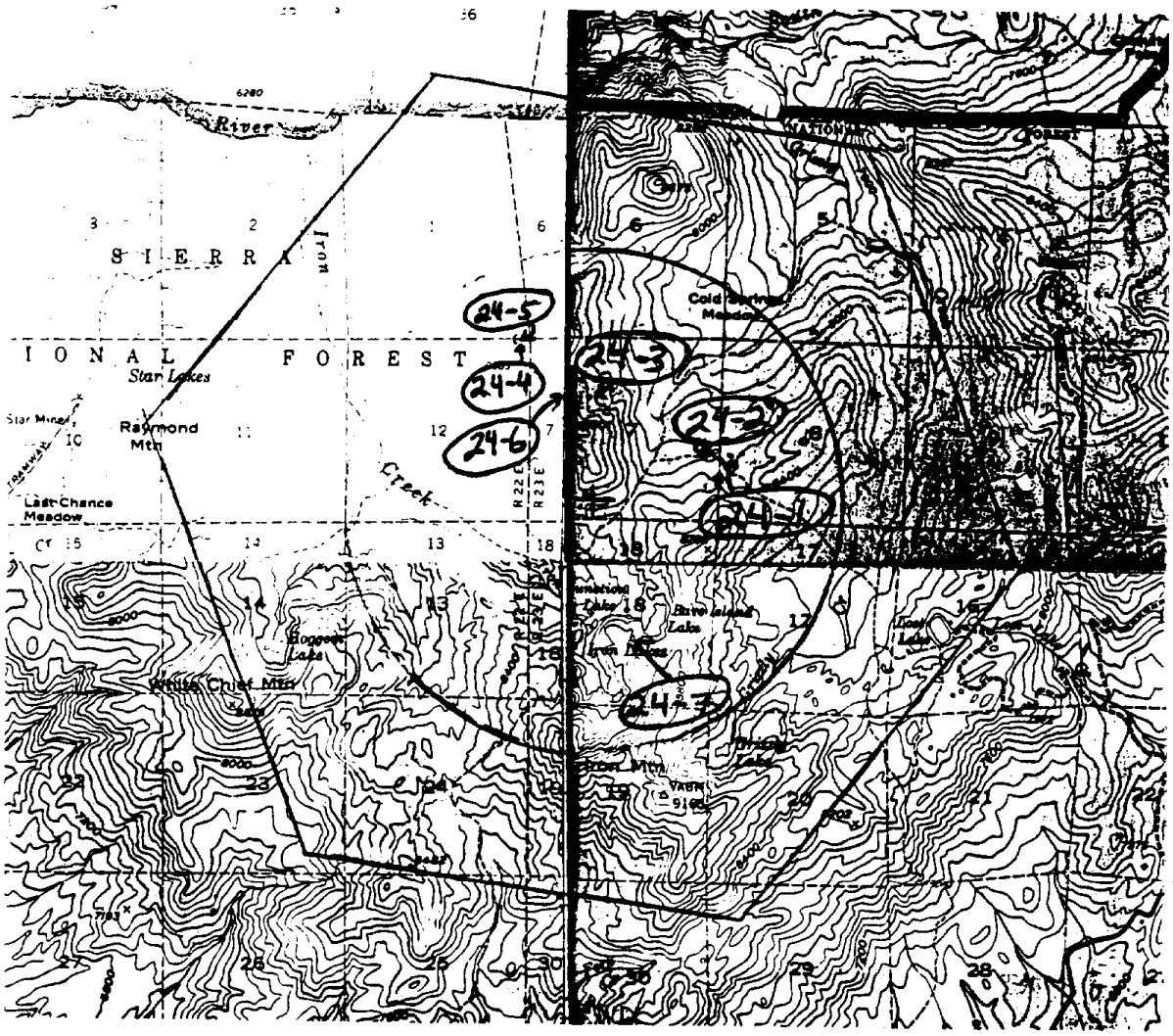
Survey Area No. 21 (7 1/2′ Quadrangle)



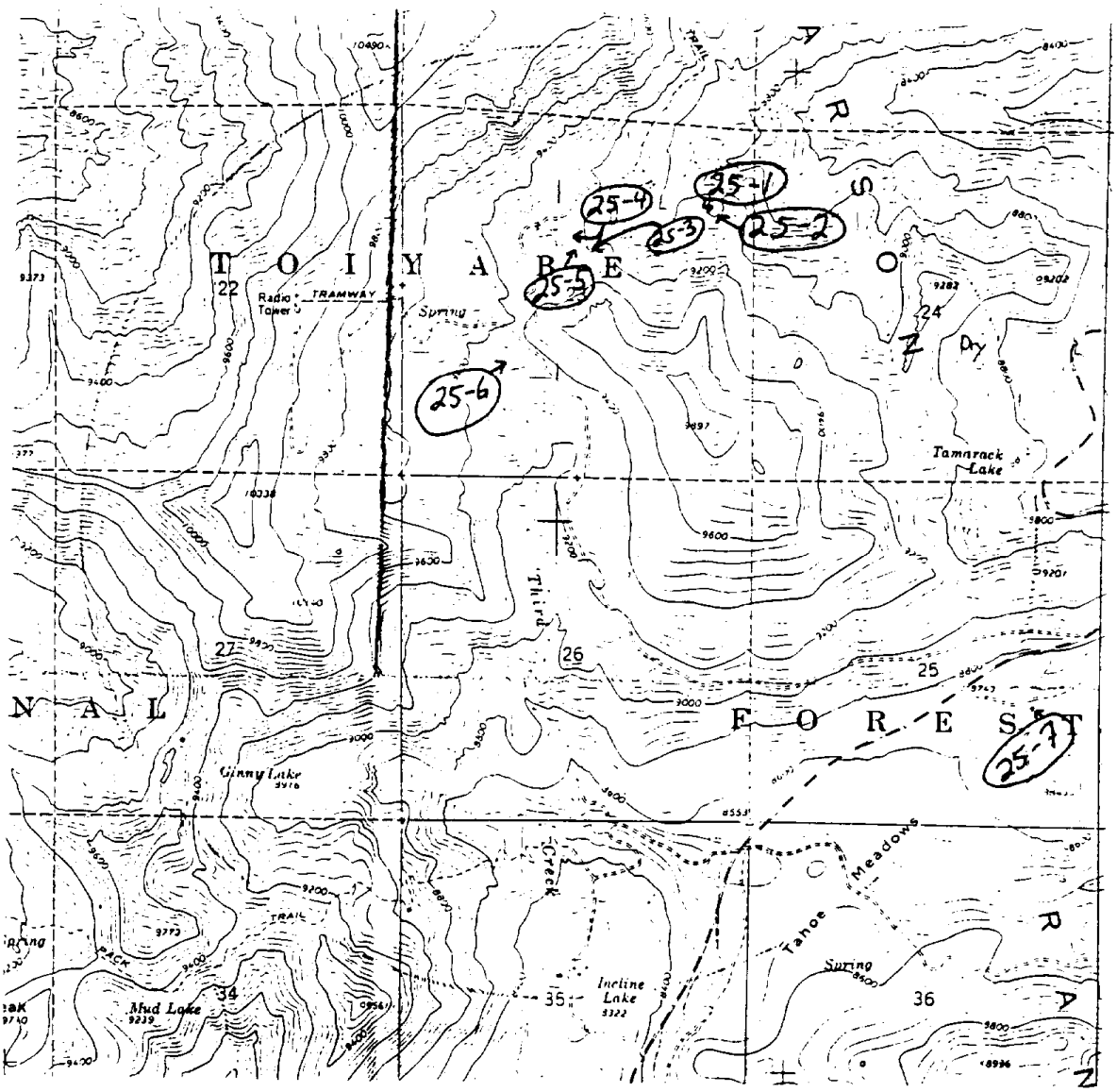
Survey Area No. 22 (7 1/2' Quadrangle)



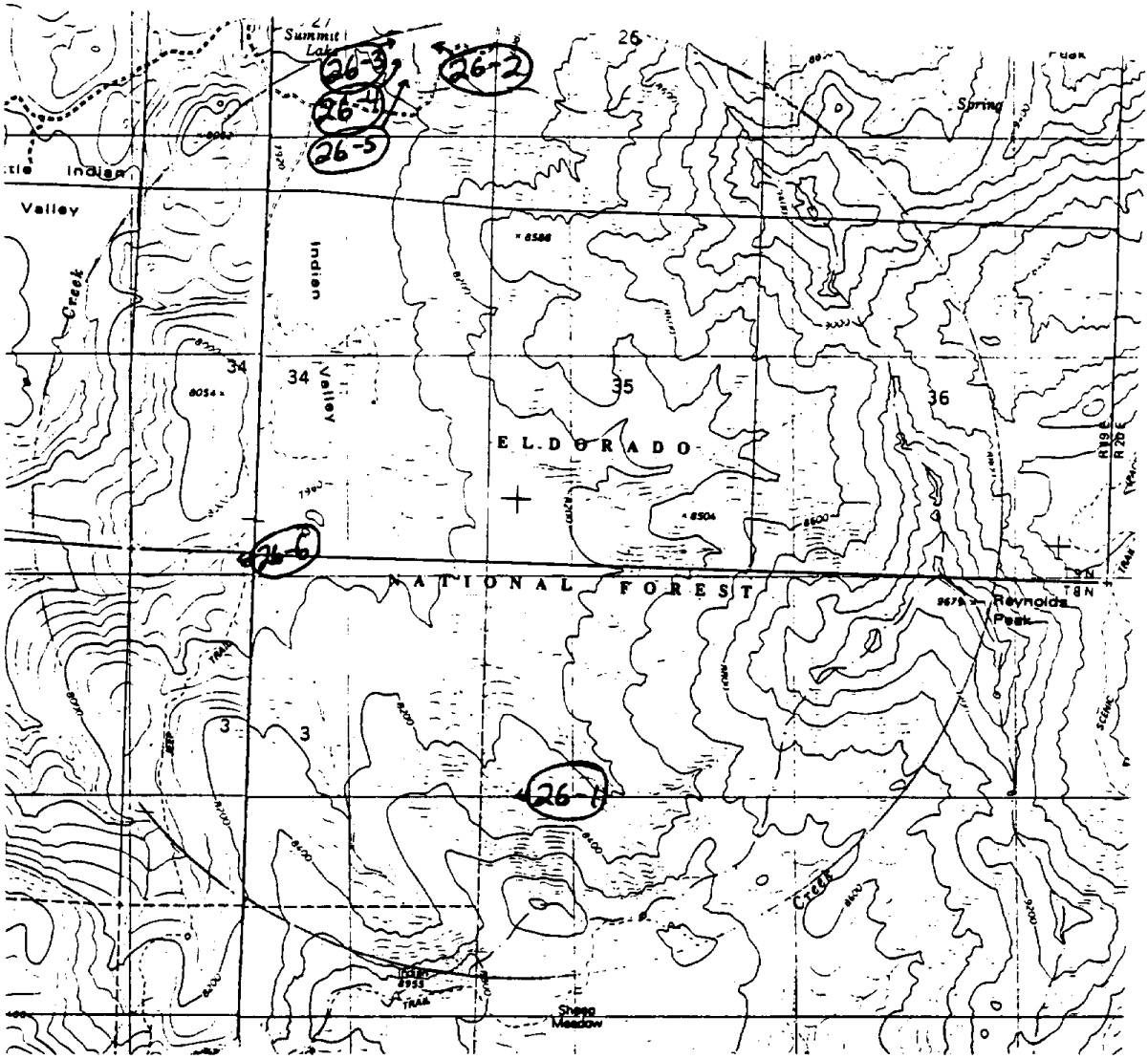
Survey Area No. 23 (15' Quadrangle)



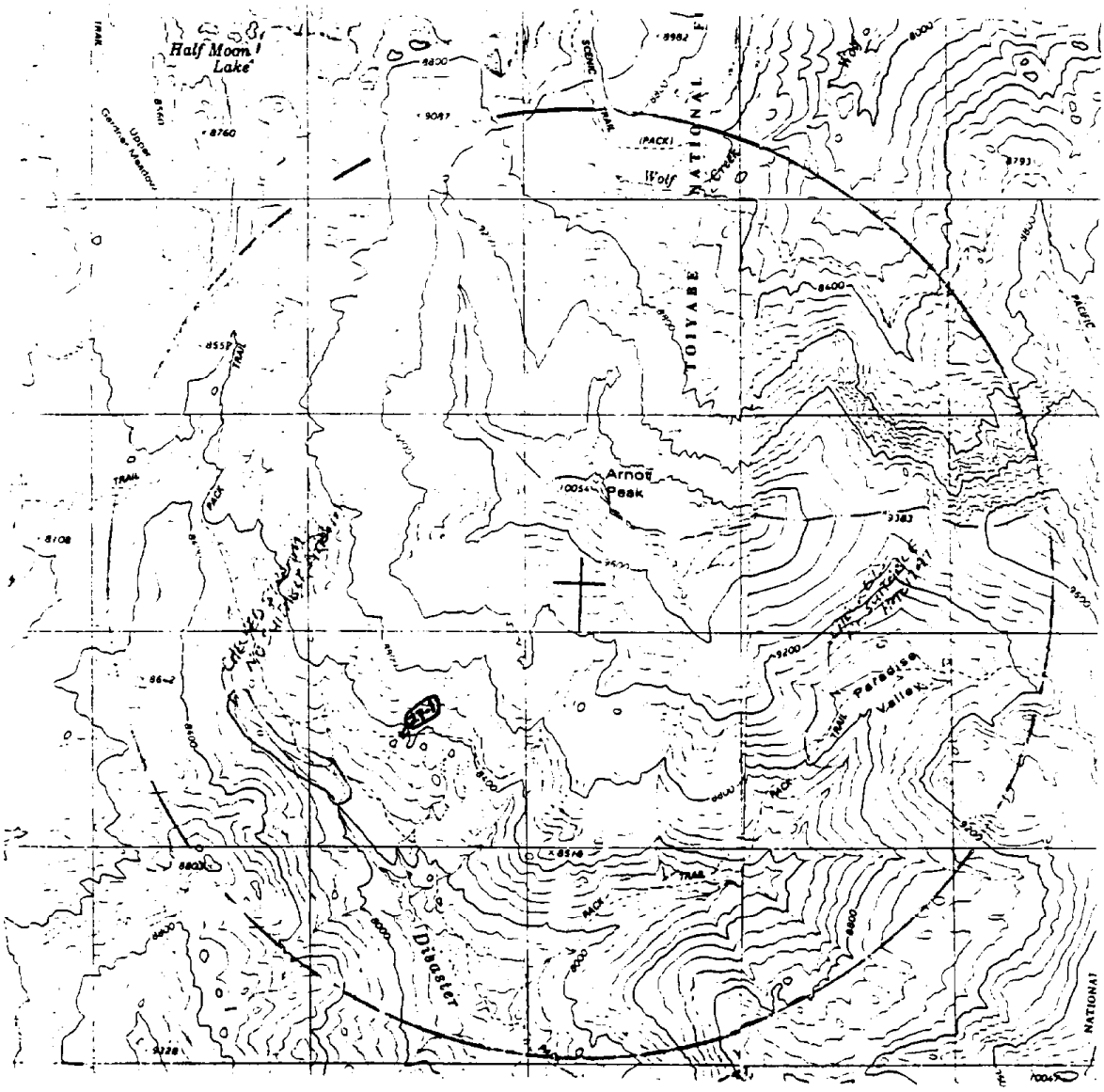
Survey Area No. 24 (15′ Quadrangle)



Survey Area No. 25 (7 1/2' Quadrangle)

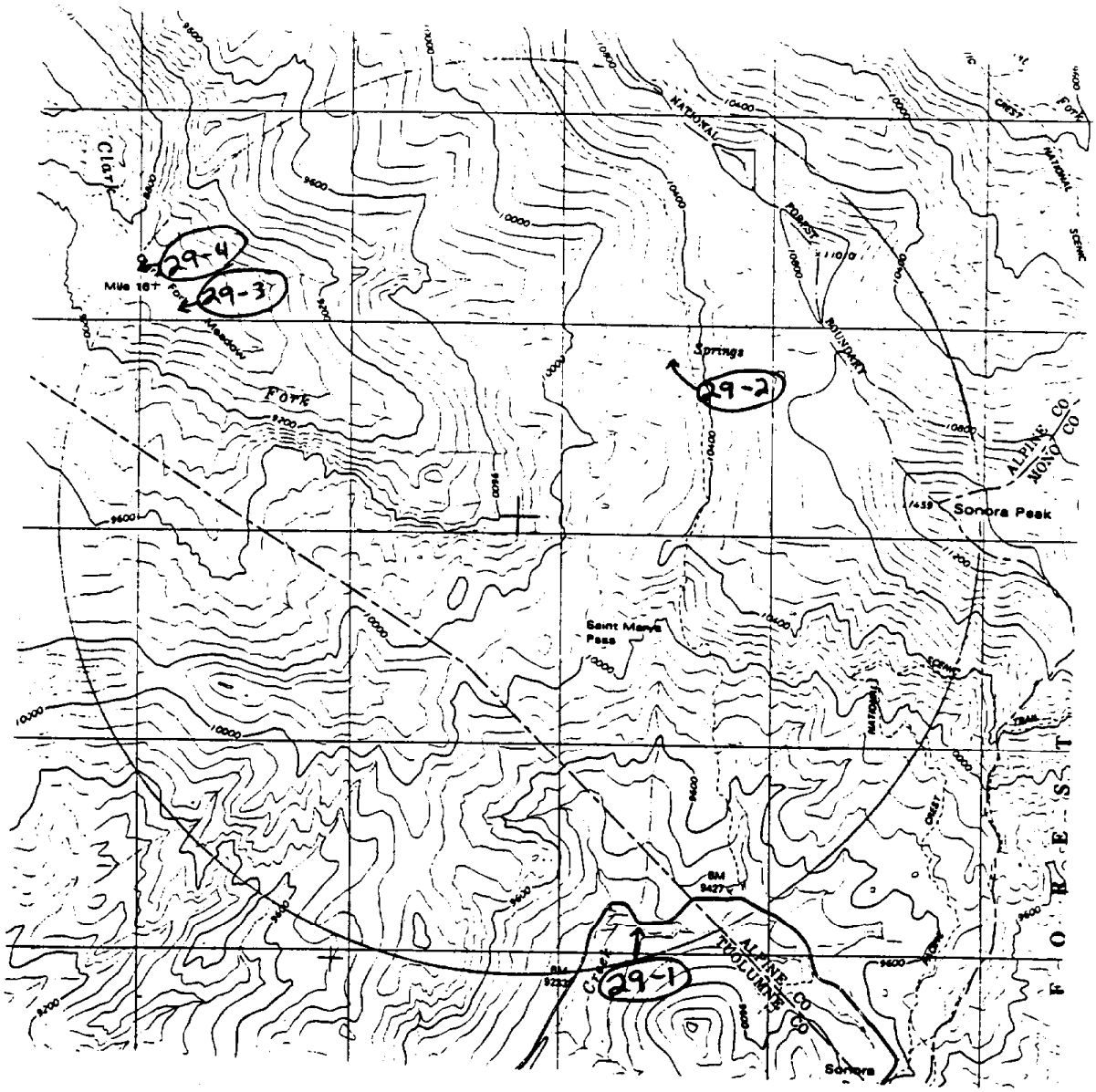


Survey Area No. 26 (7 1/2′ Quadrangle)



Survey Area No. 27 (7 1/2' Quadrangle)

Survey Area No. 28 (7 1/2' Quadrangle)



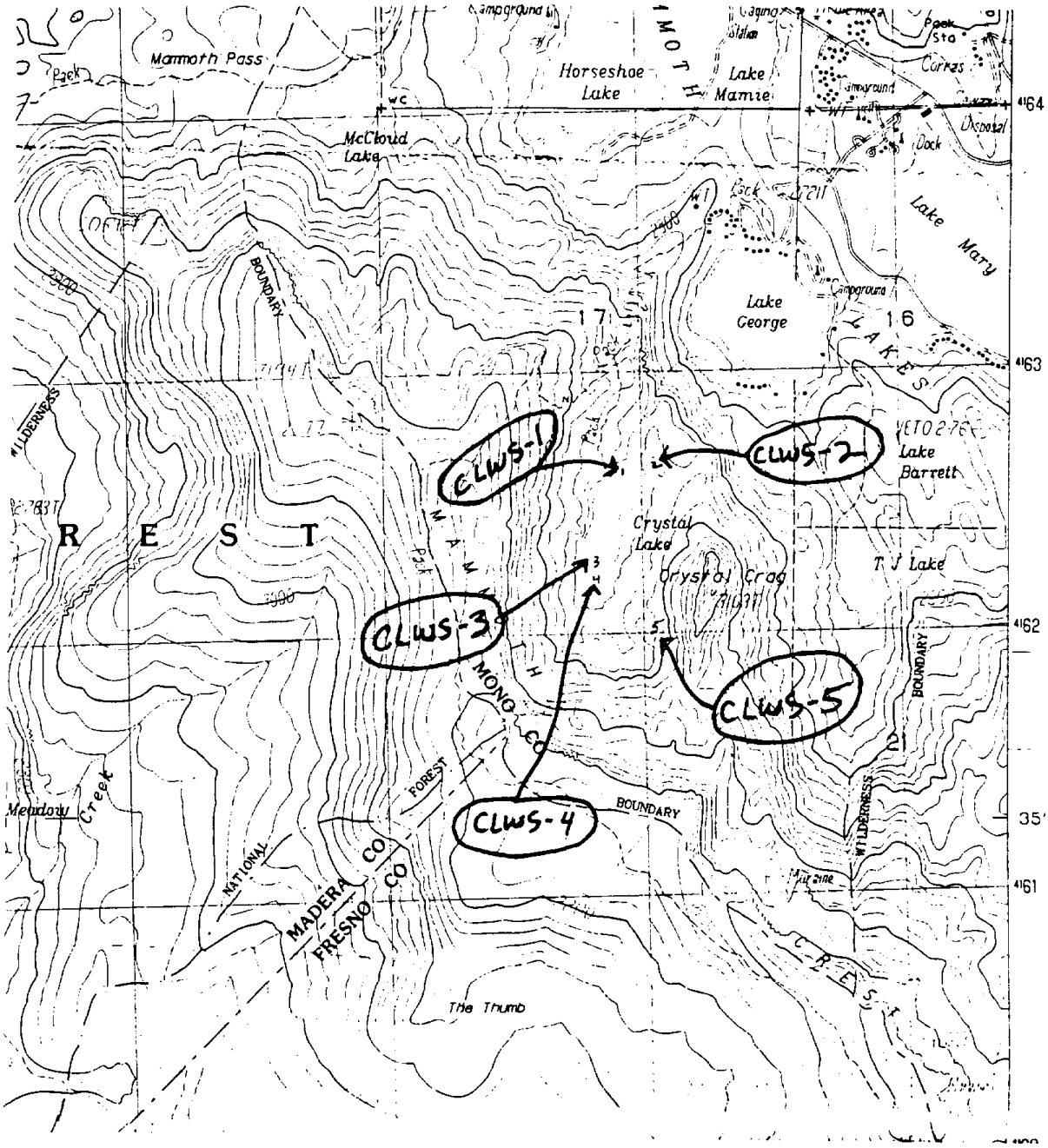
Survey Area No. 29 (7 1/2' Quadrangle)

Survey Area No. 30 (7 1/2' Quadrangle)

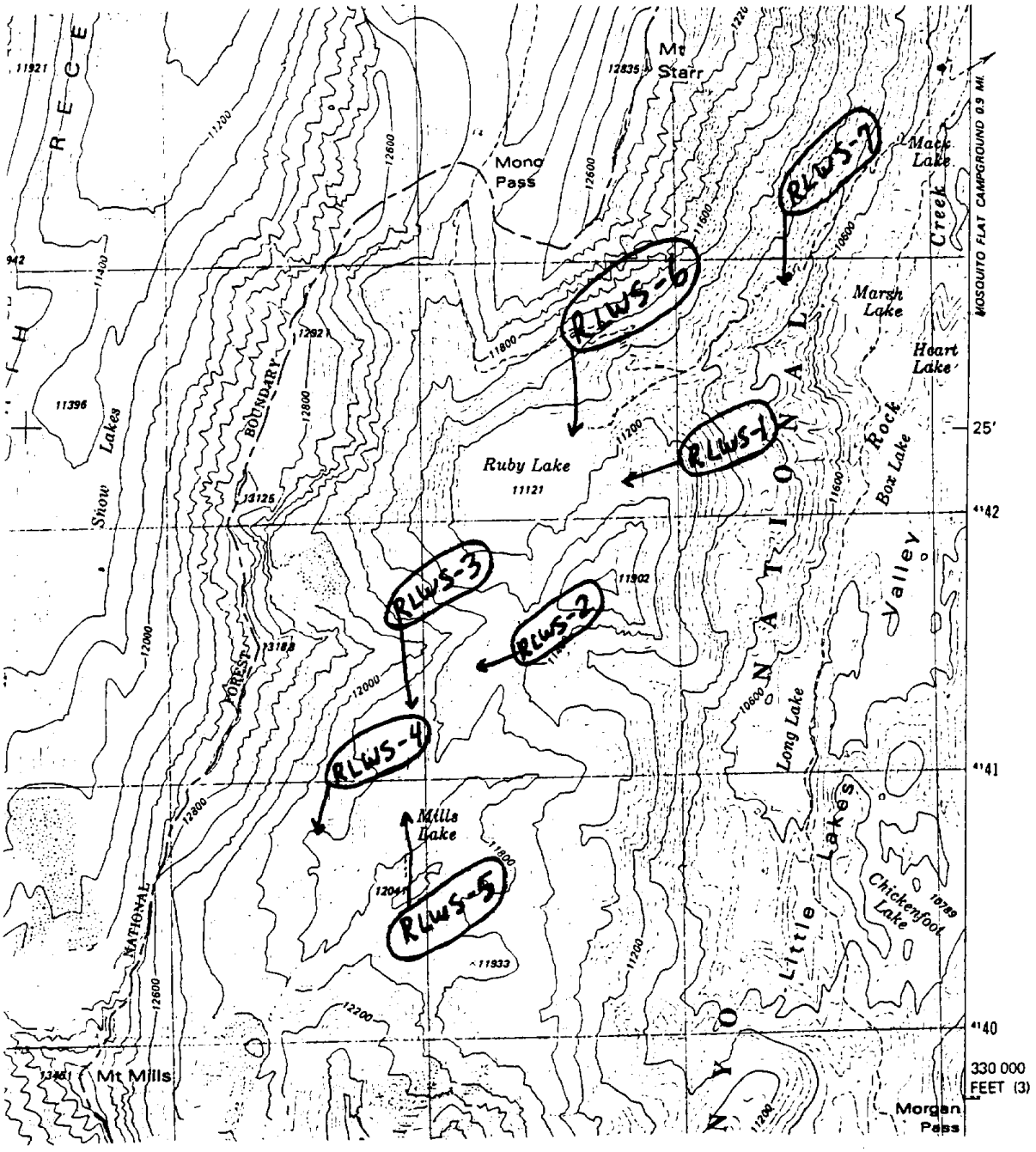
APPENDIX B

Location Maps for Sample Sites Within and Near the "Seven-watersheds" Study Areas

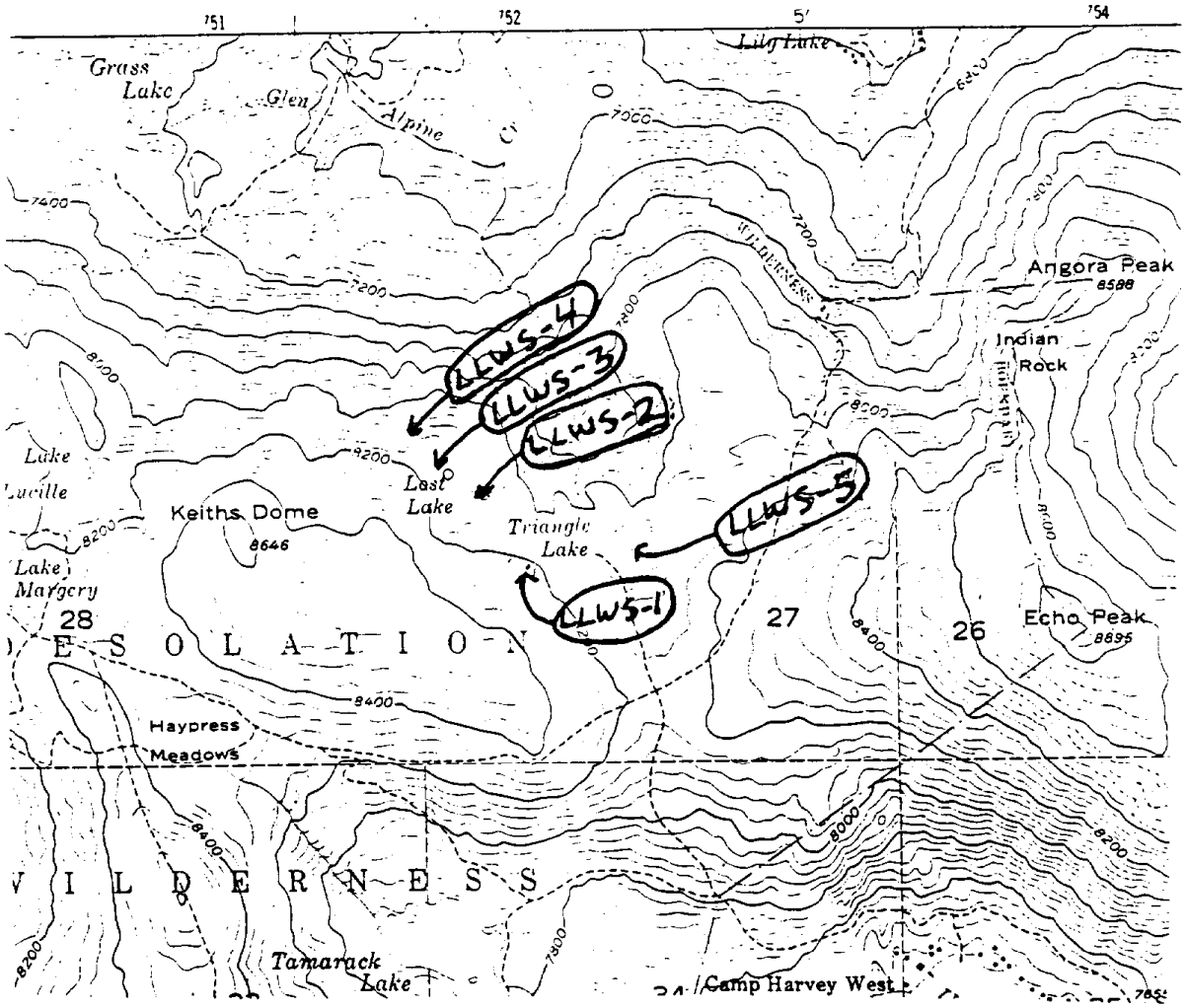
Areas surveyed include the watershed for the designated lake and, in some cases, waters in the vicinity of the watershed. Sample sites for each area are shown on 7 1/2′ or 15′ USGS quadrangles.



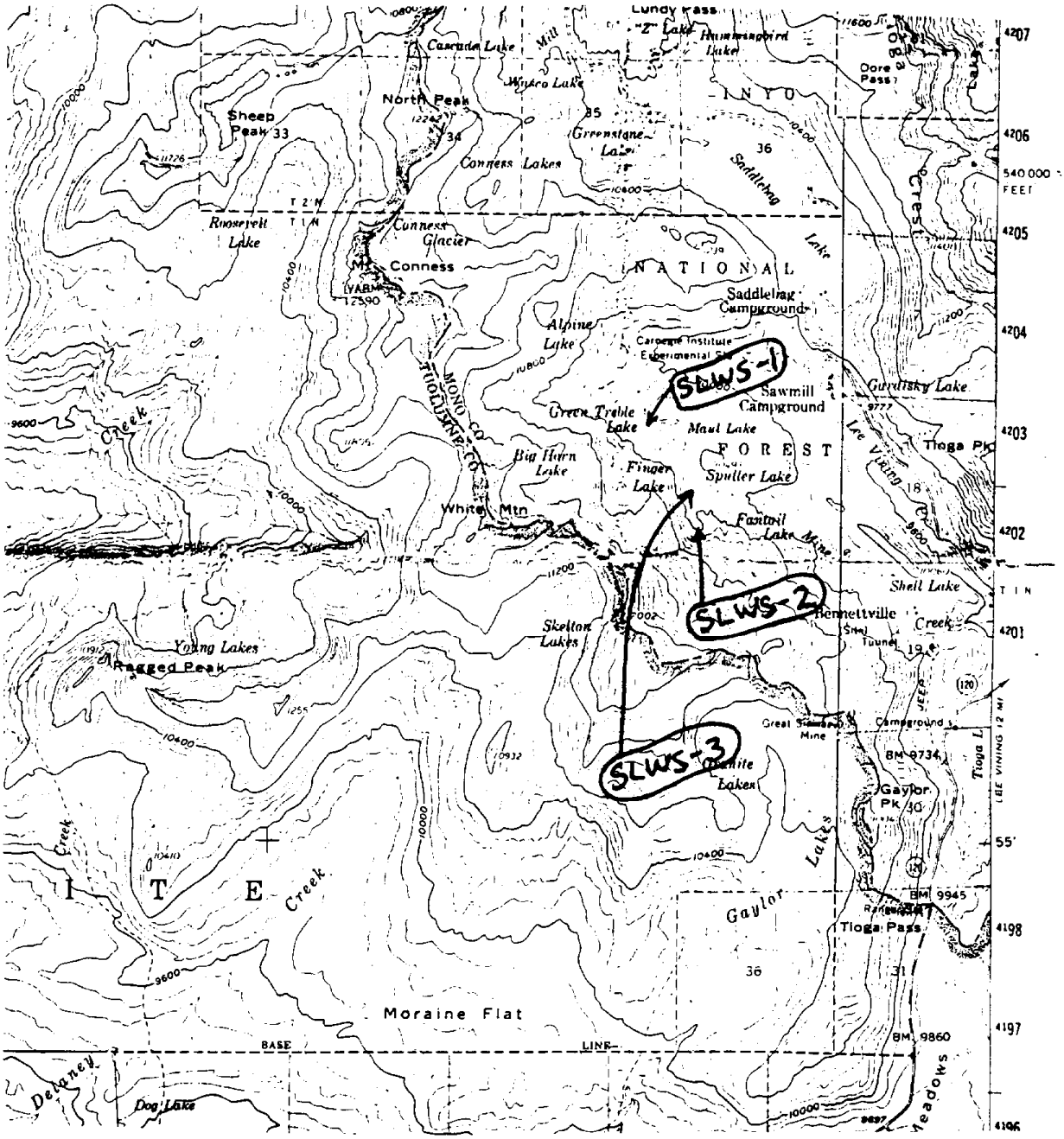
Crystal Lake Watershed and Area (CLWS)
Crystal Crag 7 1/2' Quadrangle



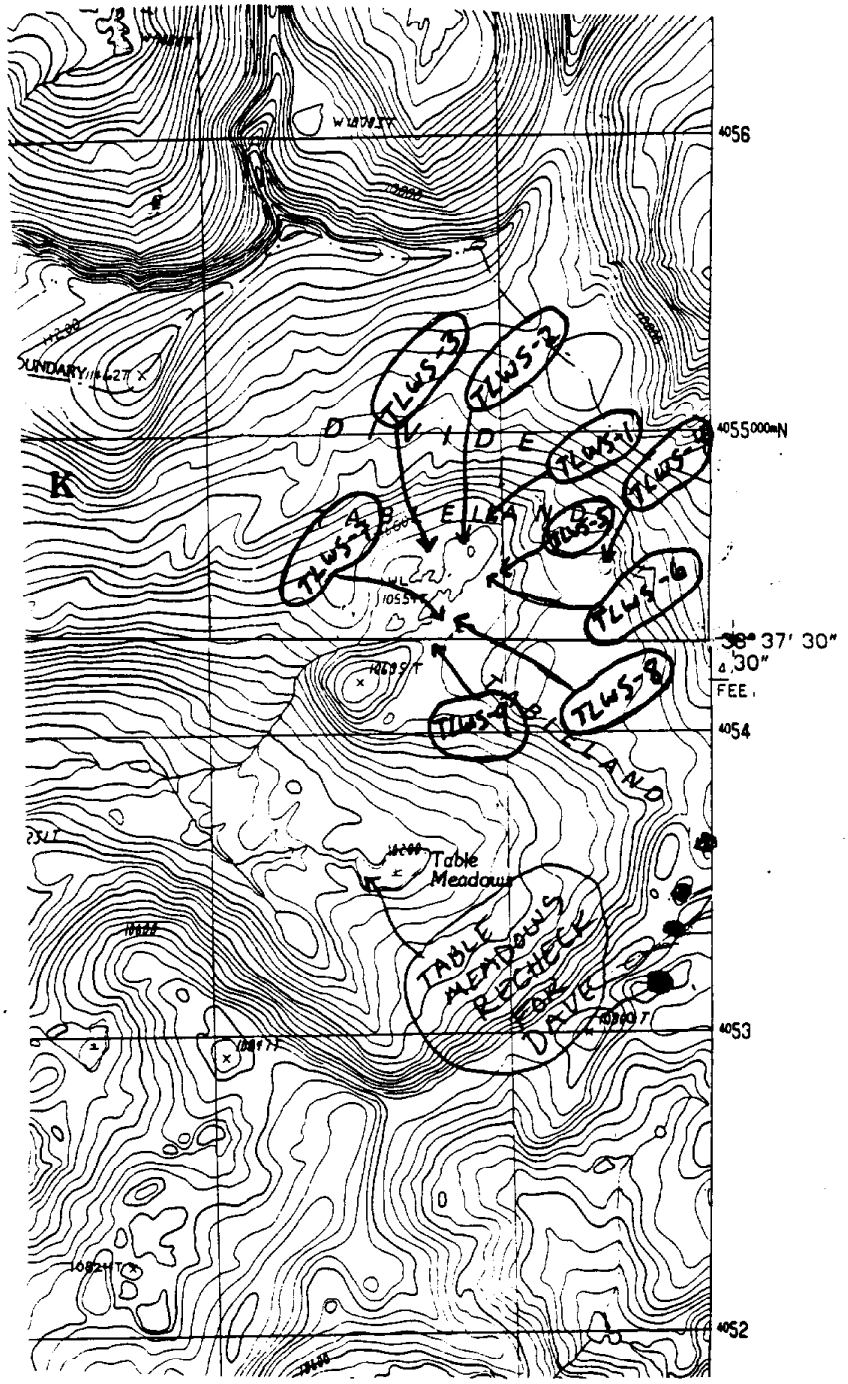
Ruby Lake Watershed and Area (RLWS)
Mt. Abbot 7 1/2' Quadrangle



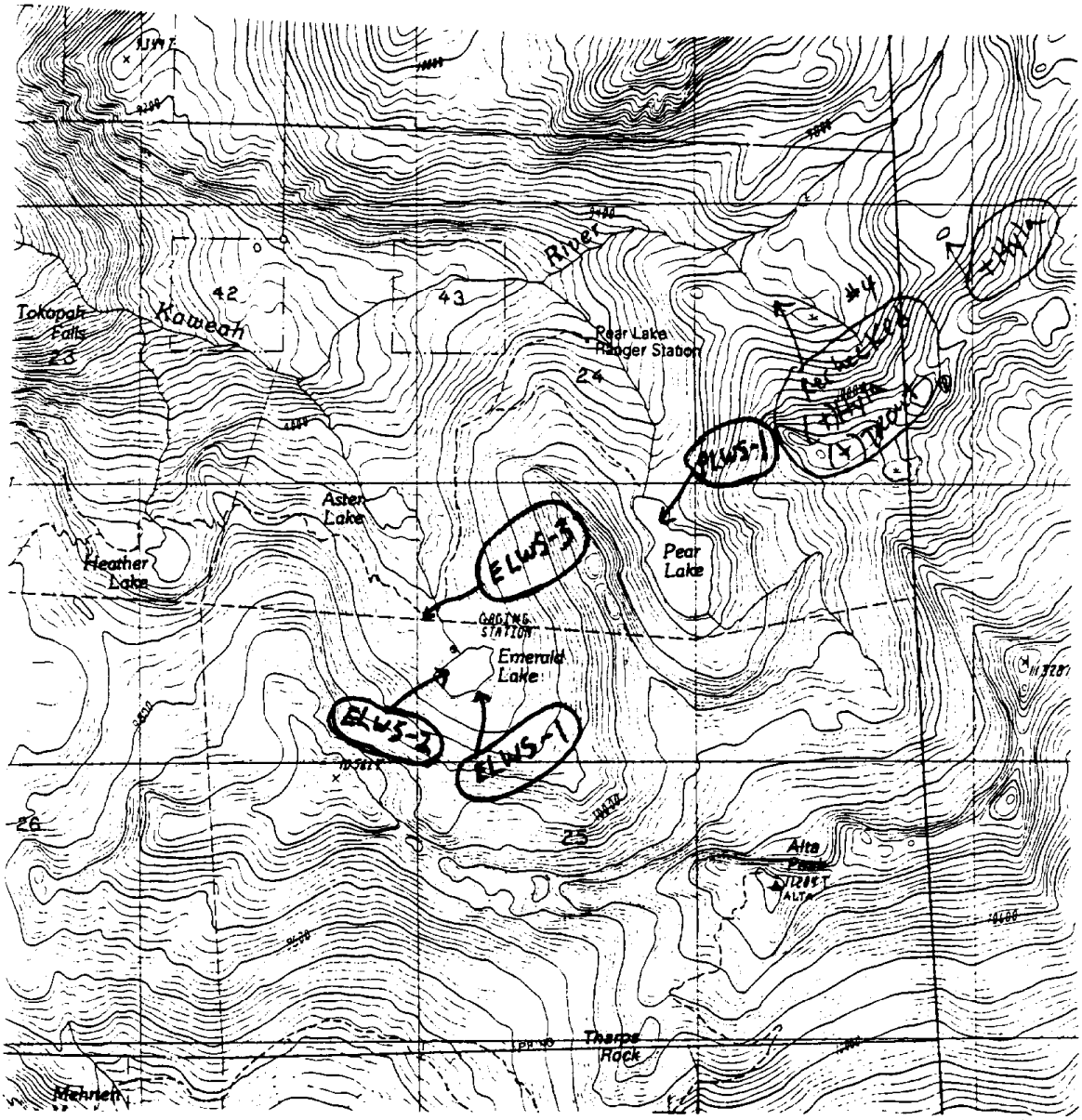
Lost Lake Watershed and Area(LLWS)
Echo Lake 7 1/2' Quadrangle



Spuller Lake Watershed and Area (SLWS)
Tuolumne Meadows 15' Quadrangle



Topaz Lake (identified as WL 10559T on map)
Watershed and Area (TLWS)
Mt. Silliman/Lodgepole 7 1/2' Quadrangles



Pear Lake Watershed and Area (PLWS) and Emerald Lake Watershed and Area (ELWS) Lodgepole 7 1/2' Quadrangle

APPENDIX C

Species Occurrence and Water Chemistry for Each Sample Site, Including "Seven-watersheds" Areas

Data variables are documented in a WordPerfect file (FLDRAW.DOC), and data are contained in a Lotus file (FLDRAW.WK1). The contents of these two files follow.

DESCRIPTION OF VARIABLES IN "FLDRAW.WK1" FILE

FLDRAW.WK1 is a Lotus file containing results of field surveys for amphibians and water chemistry in 30 survey areas, and in watersheds of "seven-watersheds" study, during 1990 and 1991. This documentation file is FLDRAW.DOC.

Variable	Description
SURV	Survey Area No.: 1 to 30 = randomly selected survey areas 101 to 107 = 7-watersheds study areas: 101 = Crystal Lake 102 = Ruby Lake 103 = Lost Lake 104 = Spuller Lake 105 = Topaz Lake 106 = Pear Lake 107 = Emerald Lake
SITE	Site No. within survey area (1 to 16)
YEAR	Year of sampling (90 or 91)
DATE	Julian date of sampling
STOR	Storage time, i.e., time between sampling and analysis (days)
DEP	Estimated maximum depth of water body: 1 = 0 to 0.50 m 2 = 0.51 to 1.00 m 3 = 1.01 to 1.50 m 4 = 1.51 to 2.00 m 5 = > 2.00 m
ELEV	Elevation (feet)
TEMP	Water temperature (°F) [missing data indicated by "-999"]
EC	Electrical conductivity (uS/cm)
PH	pH
ANC	Acid neutralizing capacity (ueq/L)

HYLA — Pseudacris (=Hyla) regilla

0 = Eggs/tadpoles not found and site not considered potential breeding habitat.
1 = Eggs/tadpoles not found but site considered potential breeding habitat.
2 = Eggs or tadpoles found.

BUBO — Bufo boreas (ID based on Karlstrom's (1962:4) range map)

0, 1, 2 as for HYLA

BUCA — Bufo canorus (ID based on Karlstrom's (1962:4) range map)

0, 1, 2 as for HYLA

BUSP — Bufo sp. (B. canorus and B. boreas combined)

0, 1, 2 as for HYLA

RANA — Rana muscosa

0, 1, 2 as for HYLA

AMBY — Ambystoma macrodactylum

0, 1, 2 as for HYLA

FISH — Fish

0 = No fish observed
2 = Fish observed

REMARKS — Remarks

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
2	1	91	205	0	2	11220	48	9.27	6.21	54.3	1	0	0	0	0	0	0	
2	2	91	205	0	1	10960	35	20.7	6.33	129.1	1	0	0	0	0	0	0	
2	3	91	205	0	1	11290	48	14.35	6.34	96.2	1	0	0	0	0	0	0	
2	4	91	205	0	1	11090	62	11.04	6.23	50.1	1	0	0	0	0	0	0	
2	5	91	205	1.5	5	11290	45	22.5	6.45	71.7	0	0	0	0	1	0	0	Fish expected
3	1	90	201	4	3	10730	67	16.1	6.11	148.7	2	0	0	0	2	0	0	
3	2	90	201	4	5	10790	74	15.7	6.1	124.8	2	1	0	1	2	0	0	
3	3	90	201	4	5	11190	65	13.1	6.5	109.8	1	0	0	0	2	0	0	
3	4	90	201	4	1	10990	78	17	6	128.6	2	0	0	0	0	0	0	
3	5	90	201	4	2	11060	69	20.1	6.55	159.2	2	0	0	0	2	0	0	
3	6	90	201	4	2	11350	72	12.2	6.1	98.6	0	0	0	0	1	0	0	
3	7	90	201	4	4	11350	69	12.3	6.46	101.7	2	0	0	0	1	0	0	One Rana adult
3	8	90	201	4	2	11120	64	35.7	6.4	306.4	1	0	0	0	0	0	0	
3	9	90	201	4	3	11120	68	35.1	6.84	294	1	1	0	1	2	0	0	
3	10	90	201	4	4	11090	76	100.3	6.32	297.4	2	1	0	1	1	0	0	
4	1	91	204	4	5	11500	60	7.73	6.35	38.2	0	0	0	0	1	0	0	
4	2	91	204	4	1	11270	63	12.24	5.96	88.5	2	1	0	1	0	0	0	
4	3	91	204	4	1	11070	62	12.65	6.36	113.9	2	1	0	1	0	0	0	
4	4	91	204	4	1	11100	58	9.93	6.17	82.3	2	1	0	1	0	0	0	
4	5	91	205	4.5	1	11000	53	16.57	5.88	138.1	2	1	0	1	0	0	0	
4	6	91	205	3	2	10820	52	47.49	6.28	149	2	0	0	0	0	0	0	
4	7	91	205	3	1	10800	67	14.1	6.17	134.5	2	1	0	1	0	0	0	
4	8	91	205	3	1	10290	68	41.1	6.39	338.1	1	2	0	2	0	0	0	
5	1	90	186	3	5	10510	66	16.1	6.81	129	1	0	0	0	0	0	2	One juvenile Hyla
5	2	90	186	3	5	10550	84	39.5	7.31	299	2	0	1	1	1	0	0	
5	3	90	186	3	1	10600	40	34.5	6.75	278	0	0	1	1	0	0	0	
6	1	90	188	2	1	11380	72	27.7	7.14	222.6	0	0	1	1	0	0	0	
6	2	90	188	2	1	11380	72	17.5	6.71	146.9	2	0	1	1	0	0	0	
6	3	90	188	2	5	11870	39	7.7	6.31	40.2	0	0	0	0	1	0	0	
6	4	90	188	2	3	11870	42	11.1	6.56	70.5	0	0	0	0	1	0	0	
6	5	90	188	2	4	11780	65	4.4	6.01	16.7	1	0	0	0	1	0	0	
6	6	90	188	2	3	10790	69	26.6	6.9	209.3	2	0	1	1	1	0	0	
6	7	90	188	2	1	10750	69	20.4	6.75	169.9	2	0	1	1	0	0	0	
6	8	90	188	2	1	10750	73	11.7	6.41	83.2	2	0	1	1	0	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
6	9	90	189	1	1	11480	49	18.6	6.59	178.5	2	0	1	1	0	0	0	
6	10	90	189	1	5	11150	59	10.8	6.61	90.3	1	0	0	0	1	0	0	
7	1	91	207	1	3	10830	56	6.64	6.43	46.2	1	0	0	0	2	0	0	
7	2	91	207	1	1	10790	58	13.58	6.61	125	1	0	1	1	0	0	0	Karlstrom's "?" range for B. canorus
7	3	91	207	1	2	11550	65	5.52	6.48	17.9	2	0	0	0	0	0	0	
7	4	91	207	1	5	11390	51	8.16	5.98	27.9	0	0	0	0	1	0	0	Adult Rana present
7	5	91	207	1	5	11070	63	8.45	6.32	58.6	0	0	0	0	1	0	0	
7	6	91	207	1	5	11115	66	10.32	6.39	69.1	1	0	0	0	2	0	0	
7	7	91	207	1	5	11020	48	7.82	5.92	24.4	1	0	0	0	1	0	0	
7	8	91	207	1	2	11220	47	4.18	5.83	15.5	1	0	0	0	0	0	0	
7	9	91	207	1	5	11580	44	3.95	5.74	9.2	0	0	0	0	1	0	0	
7	10	91	207	1	5	10180	64	5.36	6.17	37.4	1	0	0	0	1	0	0	
7	11	91	207	1	1	8220	70	19.45	6.25	157	2	0	1	1	0	0	0	Karlstrom's "?" range for B. canorus
8	1	91	210	1	4	10550	61	9.18	6.81	56.7	1	0	0	0	1	0	0	
8	2	91	210	1	2	10290	69	62.2	4.85	0.1	1	0	1	1	1	0	0	Ad. Rana pres.; "?" B. canorus range
8	3	91	210	3	1	10550	74	55.5	6.42	131.2	2	0	1	1	0	0	0	Karlstrom's "?" range for B. canorus
8	4	91	210	1	3	10550	62	81.2	4.61	-13.1	0	0	0	0	1	0	0	Adult Rana present
8	5	91	210	1	3	10790	67	6.89	6.5	41.5	2	0	0	0	1	0	0	
8	6	91	210	1	1	10400	65	17.72	5.99	33.5	2	0	0	0	2	0	0	
8	7	91	210	1	5	11380	65	26.8	6.52	116.9	0	0	0	0	1	0	0	Adult Rana present
8	8	91	210	1	5	11380	65	14.03	6.24	81.2	0	0	0	0	2	0	0	
8	9	91	210	3	3	10400	-999	8.63	6.37	37.5	0	0	0	0	2	0	0	
9	1	91	191	2	1	8960	64	31.9	5.88	290.8	2	1	0	1	0	0	0	
9	2	91	191	2	1	8920	68	22.9	6	205.8	2	2	0	2	0	0	0	"dirty" sample
9	3	91	191	2	1	8880	66	48	6.32	503.1	2	2	0	2	0	0	0	"dirty" sample
9	4	91	191	2	1	8720	68	16.43	6.1	150.2	2	1	0	1	0	0	0	"dirty" sample
9	5	91	191	2	2	8840	59	14.79	6.38	139.4	1	1	0	1	0	0	0	
9	6	91	191	2	1	8880	65	15.45	5.88	123	2	0	0	0	0	0	0	
9	7	91	191	2	1	8920	77	20.5	5.53	110.8	2	1	0	1	0	0	0	"dirty" sample
9	8	91	191	2	1	9190	70	17.11	6.62	172.9	2	1	0	1	0	0	0	
9	9	91	191	2	5	9300	72	10.91	6.39	76.6	2	1	0	1	1	0	0	
10	1	90	204	1	1	11380	63	8.9	5.61	21.4	1	0	0	0	0	0	0	
10	2	90	204	1	4	11580	62	10.1	5.65	30.5	1	0	0	0	1	0	0	
10	3	90	204	1	5	11520	64	7.2	5.98	26.8	1	0	0	0	1	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
10	4	90	204	1	5	11470	64	7.4	6.02	52.5	0	0	0	0	1	0	0	
10	5	90	204	1	1	10740	61	10.2	6.29	77.3	2	0	0	0	0	0	0	
10	6	90	204	1	4	11000	56	12.4	6.25	116.7	2	0	0	0	1	0	0	
10	7	90	204	1	1	10940	70	10.6	6.26	97.9	2	1	0	1	0	0	0	
10	8	90	204	1	5	10880	70	18.4	6.33	187.4	2	0	0	0	2	0	0	
11	1	91	198	5	5	10560	62	4.88	6	24.7	1	0	0	0	1	0	0	
11	2	91	198	5	1	9990	77	39	6.45	353.3	1	0	1	1	0	0	0	
11	3	91	198	5	5	9910	71	14.07	6.35	126.2	2	0	1	1	1	0	0	
11	4	91	198	5	1	9970	75	11.32	6.08	90.2	2	0	1	1	0	0	0	
11	5	91	198	5	1	10500	72	7.05	6.31	51.1	1	0	0	0	0	0	0	
11	6	91	198	5	2	10560	78	6.07	6	28.7	2	0	0	0	0	0	0	
11	7	91	198	5	3	10560	66	6.24	6.11	41.5	1	0	0	0	1	0	0	
12	1	91	173	2	5	9710	58	6.98	6.25	36.9	1	0	0	0	1	0	0	
12	2	91	173	2	1	9650	69	21.6	6.89	207.7	0	0	1	1	0	0	0	
13	1	91	213	2	1	11650	57	5.83	6.4	46.2	1	0	1	1	0	0	0	
13	2	91	213	2	4	11650	50	5.63	6.57	49	0	0	0	0	1	0	0	
13	3	91	214	1	5	11810	54	5.84	6.37	17.9	0	0	0	0	1	0	0	
13	4	91	214	1	1	11750	55	3.33	5.76	3	1	0	0	0	0	0	0	
13	5	91	214	1	1	10700	74	5.31	6.58	39.7	1	0	2	2	0	0	2	
13	6	91	214	1	1	10700	66	7.22	6.55	53.4	1	0	2	2	0	0	2	
13	7	91	214	1	1	10690	75	9.03	6.13	53.6	0	0	2	2	0	0	0	
13	8	91	214	1	1	10730	68	21.9	6.37	73.3	1	0	1	1	0	0	0	
13	9	91	214	1	1	10740	66	14.13	6.77	95.7	1	0	1	1	0	0	0	
13	10	91	214	1	2	10710	72	11.35	6.73	99.2	2	0	1	1	0	0	0	
13	11	91	214	1	1	10700	72	7.93	6.37	48.3	2	0	1	1	0	0	0	
13	12	91	214	1	1	10710	72	12.71	6.52	98.1	2	0	1	1	0	0	0	
14	1	90	164	4	1	8560	50	14.2	6.69	103.9	1	0	0	0	0	0	0	
14	2	90	164	4	2	8460	57	13.3	6.15	87	2	0	0	0	0	0	0	
14	3	90	164	4	1	8460	67	14.8	6.56	119.6	2	0	0	0	0	0	0	
14	4	90	164	4	1	8460	64	21.7	6.27	184.5	0	0	1	1	0	0	0	
14	5	90	164	4	5	8460	54	15.5	6.5	125.7	1	0	0	0	1	0	0	
14	6	90	164	4	5	8460	62	9.3	6.21	67	1	0	0	0	1	0	0	
16	1	90	176	1	4	9670	64	14.6	6.37	106	2	0	2	2	1	0	0	
16	2	90	176	1	1	9600	62	19.6	6.43	150	2	0	0	0	0	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
16	3	90	176	1	2	9600	62	19.3	6.22	182	2	0	0	0	0	0	0	
16	4	90	176	1	4	9600	70	14	6.69	110	2	0	1	1	1	0	0	
16	5	90	176	5	1	9580	73	22.3	6.24	203	0	0	1	1	0	0	0	
16	6	90	176	5	1	9580	61	22.2	5.95	157	2	0	0	0	0	0	0	
16	7	90	176	5	5	9570	67	12.1	6.18	89.3	2	0	2	2	1	0	0	
16	8	90	176	5	4	9580	64	11.7	5.5	37.3	1	0	0	0	1	0	0	
16	9	90	176	5	4	9580	75	8.4	5.78	37.7	2	0	1	1	1	0	0	
16	10	90	176	5	3	9580	82	194.4	7.77	1095	2	0	2	2	0	0	2	
16	11	90	176	5	1	9520	90	26.8	5.96	61.7	1	0	0	0	0	0	0	
16	12	90	176	5	1	9520	86	15.5	6.32	99.3	2	0	2	2	0	0	0	
16	13	90	176	5	1	9500	76	27.1	6.35	210	1	0	1	1	0	0	0	
16	14	90	176	5	1	9500	84	150.8	7.32	783	0	0	1	1	0	0	0	
17	1	90	187	2	2	9200	64	28.9	6.35	126.3	2	0	0	0	0	0	0	
17	2	90	187	2	2	9170	70	17.8	6.24	114.1	2	0	1	1	0	0	0	
17	3	90	187	2	2	10045	69	10.4	6.25	41.5	2	0	0	0	1	0	0	
17	4	90	187	2	5	10050	68	10	6.45	62.3	2	0	1	1	1	0	0	
17	5	90	187	2	1	10510	74	21.2	5.96	47.9	0	0	1	1	0	0	0	
17	6	90	187	2	3	10510	63	14.6	6.54	57.7	0	0	0	0	1	0	0	
17	7	90	187	3	1	8790	43	173.6	7.01	1767.6	1	0	0	0	0	0	0	
17	8	90	187	3	2	8790	55	182.9	7	2044.2	1	0	0	0	0	0	0	
17	9	90	187	3	3	8790	54	327	7.18	2284.2	1	0	0	0	0	0	0	
17	10	90	187	3	1	8790	64	488	6.48	4453.8	1	0	1	1	0	0	0	
17	11	90	187	3	2	9470	65	46.3	6.79	355.1	2	0	0	0	0	0	0	
17	12	90	187	3	3	10390	63	64.3	7.06	465	1	0	1	1	1	0	0	
18	2	91	171	4	5	7990	63	10.71	6.5	95	2	0	0	0	1	0	0	Elev. indistinct from 8000'
18	3	91	171	4	1	8810	51	22.5	6.36	229.4	1	0	0	0	0	0	0	
19	1	90	165	3	1	8860	54	9	6.34	64.2	1	0	0	0	0	0	0	
19	2	90	165	3	1	8860	57	13.1	5.55	76.3	0	0	1	1	0	0	0	
19	3	90	165	3	1	8850	67	6.5	5.93	45.2	0	0	2	2	0	0	0	
19	4	90	165	3	5	8850	79	10.1	6.29	88.9	2	0	2	2	1	0	0	
19	5	90	165	3	4	8970	59	10	5.43	27.3	2	0	0	0	1	0	0	
19	6	90	165	3	5	8670	63	14.5	6.56	142.7	2	0	0	0	1	0	0	
19	7	90	165	3	1	8670	76	9	6.1	59	0	0	1	1	0	0	0	
19	8	90	165	3	1	9080	66	11.1	5.69	78.3	2	0	0	0	0	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
19	9	90	165	3	1	9080	70	7.9	5.6	48.2	2	0	2	2	0	0	0	
19	10	90	165	4	1	9080	69	9.8	6.22	97.7	0	0	2	2	0	0	0	
20	1	90	182	3	3	8560	63	26.7	6.18	227.7	1	0	0	0	0	0	0	
20	2	90	182	3	5	8560	68	24.4	6.82	234.7	1	0	0	0	1	0	0	Fish expected
20	3	90	182	3	2	8560	59	39.1	6.16	328.4	1	0	0	0	0	0	0	
20	4	90	182	3	1	8560	65	31.2	6.38	295.9	2	0	0	0	0	0	0	
20	5	90	182	3	2	8560	67	25.1	6.32	222.2	2	0	0	0	0	0	0	
20	6	90	182	3	2	8560	68	32.1	6.29	300.1	2	0	0	0	0	0	0	
20	7	90	182	3	1	8560	65	43.4	6.56	544.7	1	0	0	0	0	0	0	
20	8	90	182	3	2	8560	70	19.3	6.36	172.3	1	0	0	0	0	0	0	May have fish
20	9	90	182	3	5	8600	80	17.2	6.66	160.3	2	0	0	0	0	0	0	May have fish
20	10	90	182	3	5	8600	74	15.1	6.45	137.8	2	0	0	0	0	0	0	
20	11	90	182	3	1	8070	73	27.2	6.32	241.1	2	0	0	0	0	0	0	
20	12	90	182	3	2	8160	73	40.2	6.59	413.4	2	0	0	0	0	0	0	
20	13	90	182	3	5	8780	72	22	6.65	200.7	2	0	0	0	1	0	0	
21	1	91	175	1	3	9470	50	7.52	5.91	19.2	2	0	1	1	1	0	0	
21	2	91	175	1	1	9410	49	8.23	5.59	39.3	1	0	2	2	0	0	0	
21	3	91	175	1	1	9050	49	4.89	5.59	19	2	0	1	1	0	0	0	
21	4	91	175	1	1	8750	51	9.79	5.94	67.4	2	0	1	1	0	0	0	
22	1	91	165	3	5	8625	67	4.64	5.85	33.2	2	0	1	1	1	0	0	
22	2	91	165	3	2	8590	70	4.47	5.6	19.1	2	0	1	1	0	0	0	
22	3	91	165	3	2	8590	65	6.09	5.54	24.2	2	0	1	1	0	0	0	
22	4	91	165	3	2	8500	67	8.32	5.91	66.4	2	0	1	1	0	0	0	
22	5	91	165	3	2	8520	66	10.39	5.8	80.3	2	0	0	0	0	0	0	
22	6	91	165	3	2	8635	61	6.19	5.43	22.2	2	0	0	0	0	0	0	
22	7	91	165	3	2	8700	62	6.08	5.35	20.9	1	0	0	0	0	0	0	
22	8	91	165	3	2	8690	62	5.26	5.62	27.9	1	0	0	0	0	0	0	
22	9	91	169	1	2	8720	56	10.33	5.91	25.6	1	0	0	0	0	0	0	
22	10	91	169	1	2	8725	57	5.17	5.59	34.4	1	0	0	0	0	0	0	
22	11	91	169	1	3	8725	58	4.14	5.82	23.5	1	0	0	0	0	0	0	
22	12	91	169	1	2	8730	65	11	5.96	81.1	2	0	1	1	0	0	0	
22	13	91	169	1	5	8730	60	4.66	5.86	25.6	2	0	0	0	1	0	0	
22	14	91	169	1	3	8740	60	4.04	5.87	19.4	2	0	1	1	1	0	0	
22	15	91	169	1	1	8740	69	5.25	5.41	23.2	0	0	1	1	0	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
22	16	91	169	1	2	8820	66	4.48	5.79	21.8	2	0	1	1	0	0	0	
23	1	90	184	1	3	10460	62	12.3	5.98	37.2	1	0	1	1	1	0	0	
23	2	90	184	1	1	10460	68	15.6	6.54	87.1	1	0	1	1	0	0	0	
23	3	90	184	1	1	10330	76	10.1	5.95	74.7	1	0	1	1	0	0	0	
23	4	90	184	1	1	10520	75	6.4	6.45	48.6	1	0	1	1	0	0	0	
23	5	90	184	1	2	10400	69	5.8	6.21	44.8	1	0	1	1	0	0	0	
23	6	90	184	1	1	10400	67	10	5.76	48.5	1	0	1	1	0	0	0	
23	7	90	184	1	1	9910	76	5.5	6.25	43.6	0	0	2	2	0	0	0	
23	8	90	184	1	1	9900	75	7.3	6.43	58.1	2	0	0	0	0	0	0	
23	9	90	184	1	1	9900	70	5.6	6.2	41.9	0	0	2	2	0	0	0	
23	10	90	184	1	1	9840	74	8.2	5.68	27.9	2	0	0	0	0	0	0	
23	11	90	184	1	1	9700	76	9.7	5.8	55.7	2	0	0	0	0	0	0	
24	1	90	166	3	3	8220	55	20.7	6.53	211.7	2	0	0	0	0	0	0	
24	2	90	166	3	2	8220	59	17.9	6.47	181.2	2	0	0	0	0	0	0	
24	3	90	166	3	2	8470	55	21.5	6.41	193.5	2	0	0	0	0	0	0	
24	4	90	166	3	5	8500	56	11.1	6.74	106.3	2	0	0	0	1	0	0	
24	5	90	166	3	1	8500	51	10.3	6.68	92.5	2	0	0	0	0	0	0	
24	6	90	166	3	1	8440	44	23.7	6.39	246.5	1	0	1	1	0	0	0	
24	7	90	167	2	3	8400	56	8.4	5.98	45.4	2	0	0	0	0	0	0	
25	1	90	170	3	3	8990	55	34.5	6.68	321.8	2	0	0	0	0	0	0	
25	2	90	170	3	3	8990	57	33.4	6.92	321.2	2	0	0	0	0	0	0	
25	3	90	170	3	1	9160	52	31.1	6.57	287.6	0	1	0	1	0	0	0	
25	4	90	170	3	1	9200	49	38.9	6.45	364.1	0	1	0	1	0	0	0	
25	5	90	170	3	1	9200	52	37.5	6.88	351.5	1	0	0	0	0	0	0	
25	6	90	170	3	5	9450	50	39.8	6.5	382.5	2	0	0	0	1	0	0	
26	1	90	174	3	2	8300	56	24	6.3	230.4	0	0	1	1	0	0	0	
26	2	90	174	3	5	8020	69	36.6	7.04	377.7	2	0	0	0	0	2	0	Ambys. observations, 7/29/91; fish expected
26	3	90	174	3	2	8030	76	7.8	5.96	32.9	2	0	0	0	1	2	0	Ambys. observations, 7/29/91
26	4	90	174	3	5	8030	70	8.8	5.88	50.3	2	0	0	0	1	2	0	Ambys. observations, 7/29/91
26	5	90	174	3	3	8030	73	8	5.53	25.7	2	0	0	0	0	2	0	Ambys. observations, 7/29/91
26	6	90	174	3	1	7960	78	27.8	6.45	267.2	2	0	1	1	0	0	0	Ambys. observations, 7/29/91
26	7	90	174	3	1	8070	78	45.4	7.19	463.7	2	0	1	1	0	2	0	Ambys. observations, 7/29/91
27	1	91	183	1	2	8320	75	69.7	7.88	837	2	0	0	0	0	1	0	
28	1	91	196	1	1	8040	50	10.96	6.06	73.9	1	0	1	1	0	0	0	

SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
28	2	91	196	1	5	8580	65	9.94	6.21	43.1	2	0	0	0	1	0	0	
28	3	91	196	1	5	8900	63	3.28	5.96	16.1	1	0	0	0	2	0	0	
28	4	91	196	1	2	8790	77	7.61	6.12	51.8	2	0	2	2	0	0	0	
28	5	91	196	1	1	8960	65	9.23	5.99	69.8	2	0	2	2	0	0	0	
28	6	91	196	1	5	9180	76	4.21	5.76	7.1	1	0	0	0	2	0	0	
28	7	91	196	1	1	9120	69	8.96	5.59	33.2	1	0	0	0	0	0	0	
28	8	91	196	1	1	9120	66	3.68	5.74	8.5	2	0	0	0	0	0	0	
28	9	91	196	1	4	9270	67	5.93	6.05	10.5	1	0	0	0	1	0	0	
28	10	91	196	1	5	8920	65	4.07	6.24	17.7	1	0	0	0	2	0	0	
28	11	91	196	1	3	9590	65	5.12	6.29	20.3	1	0	1	1	1	0	0	
28	12	91	196	1	2	9190	66	3.74	5.92	18.6	1	0	1	1	1	0	0	
28	13	91	196	1	1	8790	70	11.87	5.9	73.6	2	0	2	2	0	0	0	
29	1	90	175	2	1	9720	58	24.2	6.21	208.7	1	0	1	1	0	0	0	
29	3	90	175	2	1	8820	58	41.5	6.9	412.5	1	0	1	1	0	0	0	
29	4	90	175	2	1	8820	55	94.3	7.18	995.7	1	0	1	1	0	0	0	
30	1	91	187	2	4	8895	67	4.7	5.8	31.1	2	0	1	1	2	0	0	
30	2	91	187	2	5	8895	59	5.94	5.93	46.3	2	0	0	0	1	0	0	
30	3	91	187	2	2	8910	62	6.36	5.8	52.7	2	0	0	0	0	0	0	
30	4	91	187	2	2	8890	64	4.98	5.68	13.1	2	0	0	0	0	0	0	
30	5	91	187	2	5	8975	64	3.57	5.82	18.1	2	0	1	1	2	0	0	
30	6	91	187	2	2	8330	68	4.81	5.39	16.3	2	0	0	0	0	0	0	
30	7	91	187	2	3	9190	70	3.18	5.73	-1.5	0	0	0	0	2	0	0	
30	8	91	187	2	2	9190	72	4.06	5.65	29.2	2	0	1	1	0	0	0	
30	9	91	187	2	4	9230	74	3.47	5.69	7.2	2	0	1	1	2	0	0	
30	10	91	187	2	3	9220	73	3.73	5.63	8.1	2	0	0	0	2	0	0	
30	11	91	187	2	2	9310	79	4.91	5.7	11.9	2	0	0	0	0	0	0	
30	12	91	187	2	3	9425	75	3.71	5.59	16.3	2	0	0	0	2	0	0	
30	13	91	187	2	3	9310	74	2.77	5.74	3.6	2	0	1	1	1	0	0	Adult Rana present
30	14	91	187	2	3	9830	51	2.78	5.52	10.1	0	0	0	0	1	0	0	
30	15	91	187	2	3	9620	65	3.31	5.81	13.4	2	0	1	1	1	0	0	
30	16	91	188	1	3	9700	58	2.63	5.74	1.1	2	0	1	1	2	0	0	
101	1	90	206	3	5	9630	59	18.4	6.41	74.8	0	0	0	0	0	0	2	
101	2	90	206	3	3	9660	75	7.2	6.01	41.9	2	0	0	0	1	0	0	
101	3	90	206	3	1	9630	71	12.2	6.43	96.8	1	0	1	1	0	0	0	

ASSET
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SURV	SITE	YEAR	DATE	STOR	DEP	ELEV	TEMP	EC	PH	ANC	HYLA	BUBO	BUCA	BUSP	RANA	AMBY	FISH	REMARKS
101	4	90	206	3	1	9630	70	8.9	6.19	73.5	2	0	1	1	0	0	0	
101	5	90	206	3	2	9810	66	8.4	5.89	28	1	0	0	0	0	0	0	
102	1	90	207	2	1	11260	76	25.7	6.09	38.2	1	0	0	0	0	0	0	
102	2	90	207	2	3	11510	60	15.7	6.28	43.6	0	0	0	0	1	0	0	
102	3	90	207	2	3	11650	59	13.3	6.39	47.6	0	0	0	0	1	0	0	
102	4	90	207	2	2	11790	60	8.1	6.28	36.6	0	0	0	0	1	0	0	
102	5	90	207	2	5	11650	59	9.4	6.18	32.6	0	0	0	0	1	0	0	May have fish
102	6	90	207	2	5	11121	58	13.2	6.39	52.7	0	0	0	0	0	0	2	
102	7	90	207	2	2	10890	67	19.8	6.62	189	2	0	0	0	0	0	0	
103	1	90	208	1	1	8240	80	29.3	6.18	61.1	2	0	0	0	0	1	0	
103	2	90	208	1	5	8110	76	8.8	5.99	32.4	0	0	0	0	0	0	0	Fish known present
103	3	90	208	1	2	8180	78	10.4	5.76	34.5	2	0	0	0	0	2	0	
103	4	90	208	1	1	8150	80	11.7	6.37	71.6	2	0	0	0	0	1	0	
103	5	90	208	1	2	8030	78	11.4	6.03	68.5	1	0	0	0	0	2	0	
104	1	90	209	0	1	10220	77	8.4	6.16	39.6	0	0	0	0	0	0	2	
104	2	90	209	0	2	10380	59	7	6.33	44	1	0	0	0	0	0	0	
104	3	90	209	0	5	10280	64	7.3	6.51	49.2	0	0	0	0	0	0	2	
105	1	91	192	1	1	10560	53	5.24	5.84	34.9	2	1	0	1	0	0	0	
105	2	91	192	1	5	10560	60	3.75	6.22	23.2	1	0	0	0	1	0	0	
105	3	91	192	1	3	10560	58	6.61	5.44	21	1	1	0	1	0	0	0	
105	4	91	192	1	1	10670	59	6	5.77	40.8	2	1	0	1	0	0	0	
105	5	91	192	1	2	10570	59	6.41	5.97	55.7	1	0	0	0	0	0	0	
105	6	91	192	1	2	10575	61	3.61	5.9	23.6	1	0	0	0	0	0	0	
105	7	91	192	1	1	10560	63	8.01	5.96	55.9	1	1	0	1	0	0	0	
105	8	91	192	1	1	10570	67	4.86	5.63	28.4	1	1	0	1	0	0	0	
105	9	91	192	1	3	10570	64	5.95	6.09	53.9	1	0	0	0	1	0	0	Adult Hyla present
106	1	91	192	1	5	9550	61	4.15	5.94	22.3	0	0	0	0	0	0	2	
107	1	91	192	1	1	9240	82	3.76	5.79	15.4	1	1	0	1	0	0	0	
107	2	91	192	1	5	9230	59	5.12	5.93	18.9	0	0	0	0	0	0	2	
107	3	91	192	1	1	9230	79	8.62	5.77	40.1	2	0	0	0	0	0	0	

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Toxicity testing indicated that amphibians are at little risk from low pH in waters acidified to a pH of 5.0 and aluminum concentrations from 39 to 80 ug/1. However, sublethal effects (reduced growth rate and earlier hatching) were observed for pH as high as 5.25 and the aluminum concentrations tested. We tested the hypothesis that acidification of habitats in the field has resulted in elimination of populations from waters most vulnerable to acidification, i.e., low in pH or ANC, or from waters low in ionic strength a condition that increases the sensitivity of amphibians to low pH. We surveyed potential breeding sites for two declining and one non-declining species at high elevation within 30 randomly selected survey areas, and compared chemical parameters between sites containing a species and sites lacking the species. No significant differences were found that were consistent with the hypothesis, and water chemistry did not differ among sites inhabited by the three species. These findings imply that acidic deposition is unlikely to have been a cause of recent amphibian population declines in the Sierra Nevada.

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