UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Survey of helium in natural water wells and springs in southwest Montana and Imperial Valley, California Part VI - Jan. 1 - Dec. 31, 1983

by

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Survey of helium in natural water wells and springs in southwest Montana and Imperial Valley, California

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This report is of a continuing project begun in 1977 to evaluate a method to predict earthquakes. It involves a comparison of significant changes in helium found in natural water wells and springs with recorded earthquakes in the immediate vicinity of the wells or springs. A positive correlation was reported in the research done by Bulasevich and Bashorin (1974). Work in previous years on this project is reported by Doering and others (Doering and Friedman, 1980a, 1980b, 1982, 1983, and Doering and others, 1981).

We received water samples from eight wells and four springs situated northwest of Yellowstone National Park and from four wells in the Imperial Valley of southern California. These sixteen stations located in the Hebgen Lake area of Montana and southern terminus of the San Andreas fault zone of California were chosen because the water contains measurable amounts of helium and they are in active seismic regions. We received samples from all but three of these stations during all of the year 1983. Table 1 gives a short description of these stations and Figures 1 and 2 shows their approximate location on maps.

The sample collectors withdraw about 9 milliliters of well or spring water into a plastic syringe and then injected it into a partially evacuated collection tube. A sample is usually taken once a day. When five tubes are thus filled they are mailed to the Geological Survey laboratory at the Denver Federal Center. The gas in the ullage space above the water in the sample tube is extracted and analyzed for helium on a mass spectrometer. The method is described in Doering and others, 1981.

The analytical precision is ±5%. An additional ±15% estimated error is due to station variations such as water temperature, amount of water collected, the rate at which water is collected and daily time of sample collection. At the well stations the helium concentrations may be affected by the quantity of water being pumped just before the sample was taken. The daily record of the amount of helium present at each station is shown on Figures 3 through 19. Four scales are used on the graphs because there are large helium concentration differences between stations. There are a total of 8,340 individual analysis reported. Numerical (Julian) dates are given on these graphs but they may be converted to normally used calendar dates by use of Figure 20.

The National Earthquake Information Service located at Golden, Colorado reported six earthquakes having a magnitude greater than 3.5 that occurred in the areas shown in figures 1 and 2 during 1983. Table 2 lists the date, epicenter location and magnitude of the two earthquakes that occurred in the Imperial Valley and four earthquakes close to the Montana sampling network. These quakes are indicated by tick marks and labeled "EQ" on the dates of occurrence on the graphs of Figures 3 through 19.

Table 3 presents a summary of the helium data as related to changes in helium and earthquakes. These changes are listed by station number and Julian date. A + indicates there was a significant increase and a - indicates a significant decrease in helium beginning with the date shown and continuing for over 5 days. A significant change is defined as a helium variation exceeding 20% of the average amount present that continues for at least 5 days. The dates of earthquakes are shown in column three. Column four shows the relationship of helium changes to earthquakes. A + indicates there was a change in helium preceeding or about the same time as the occurrence of an

earthquake. A - indicates there was a change in helium but no earthquake the preceeding 30 days. At station 316 there was a sudden decrease in helium on day 146 (May 26) and a gradual increase beginning about day 314 (Nov. 10). This has occurred every year since 1980 when collecting was begun. These changes coincide with irrigation in the nearby fields.

Table 1.--Localities of helium-sampling stations

Station No.	Station Name	Address	Comments
300	Miller	Dick Miller River Route, Box 490 Gardiner, MT 69030	58.5 m (192 ft) deep well; pump at 50.3 (165 ft); pumped continuously at 7.6 lpm (2 gpm); water temp. 67°C, (153°F). This well is about 300 m (984 ft) from a small warm spring, and 1000 m (3281 ft) from La Duke Hot Springs, a large hot spring. The water is high in fluorine and iron.
301	Beer	Paul Hantelmen U.S.G.S. Box 1049 West Yellowstone, MT 59758	61 m (200 ft) deep well; water source for service facility at Yellowstone National Park.
305	Veronda	Guida Veronda Star Route 1 Box 78 Ennis, MT 59729	Domestic well, over 61.0 m (200 ft) deep.
307	Hunter's	Harold Johnson Box 132 Springdale, MT 59082	Hunter's Hot Springs.
308	Lapp	Allen L. Lapp Box 503 West Yellowstone, MT 59758	Town well, 67.7 m (222 ft) deep; cased to 45.7 m (150 ft).
310	Chico	Mrs. Rosemary Bernethy Box 3 Pray, MT 59065	Hot Spring.
313	Orr	Wesley Orr Ennis National Fish Hatchery, Ennis, MT 59729	Flowing spring; 1515 lpm (400 gpm); water temp. is 12°C (54°F).
314	Bozeman	E. M. Drake 133 Lower Rainbow Rd. Box 21 Bozeman, MT 59715	Well that taps Bozeman Hot Spring, 167.6 m (550 ft) deep, having a flow of 2841 l pm (750 gpm); water temp. is 53.9°C (129°F).

Table 1.--Localities of helium-sampling stations (Cont'd)

Station No.	Station Name	Address	Comments
316	Blakeley	Shirley Blakeley Route 38 Box 2249 Livingston, MT 59047	119 m (390 ft) fully cased well.
317	MacMillan	Richard MacMillan P. O. Box 761 Ennis, MT 59729	Domestic well, 42.7 m (140 ft) deep; 113.8 lpm (30 gpm) flow; water contains H_2S; temp. is 53.3°C (128°F).
318	Thexton	Alex Yenny P. O. Box 748 Ennis, MT 59729	Thexton Hot Springs, water temp. is 84°C (183°F).
321	Murphy	Jim Murphy Ox Yoke Ranch Emigrant, MT 59027	79.2 m (260 ft) deep well; perforated from 45.7-68.6 m (150-225 ft).
343	Blevins	Roy Blevins 5605 Butters Road Brawley, CA 92227	Old well of unknown depth, dug 50 years ago; temp. about 60°C (140°F).
344	Bowles	Mrs. Charles Bowles Box 74 Calipatria, CA 92233	356 m (1167 ft) deep artesian well; cased to 305 m (1000 ft); 663 lpm (185 gpm); temp. is 41.1°C (106°F).
348	White	Mrs. Dorothy White P. O. Box 184 Ocotillo, CA 92259	88.4 m (290 ft) deep well.
349	Rodia	Jim Rodia P. O. Box 86 Ocotillo, CA 92259	183 m (600 ft) deep well; temp. is 33°C (92°F).

Table 2.--Earthquakes in reporting areas in 1983

Julian date	Calendar date	Latitude N.	Longitude W.	Region	Magnitude
12	Jan. 12	31.53	115.69	S.W. of ElCentro, CA	4.5
37	Feb. 6	44.56	110.64	N. of West Thumb, YNP, WY	4.7
47	Feb. 16	45.94	111.51	Near Three Forks, MT	3.7
194	July 13	33.26	115.56	N. of Calipatria, CA	4.2
225	Aug. 13	44.72	111.80	W. of West Yellowstone, MT	3.9
226	Aug. 14	44.76	111.80	W. of West Yellowstone, MT	4.1

Table 3.--Dates of significant He changes and correlation with earthquakes

Station No.	Julian date of start of significant He change (+increase, -decrease)	Date(s) of earthquake(s)	Significant He change and earthquake correlation (+ earthquake, - no earthquake)
300		37	-
300		47	-
300	59+		-
300		225,226	-
301		37	-
301		47	-
301	162+		-
301		225,226	-
305	30+	37	+
305	34-	37	+
305	40-	47	+
307	37+	37	+
307	43-	47	+
307	203-	225,226	+
308	13+		+
308	27-	37	+
308		47	-
308	52-		-
308	118-		-
308	128+		-
308	224+	225,226	+
308	251+		-
313	21-	37	+
313	42-	47	+
313	49-		-
313	181-		-
313		225,226	-
314		37	-
314		47	-
314	58+		-
314	182+		-
314	214+	225,226	+

Table 3.--Dates of significant He changes and correlation with earthquakes, (Cont'd)

Station No.	Julian date of start of significant He change (+increase, -decrease)	Date(s) of earthquake(s)	Significant He change and earthquake correlation (+ earthquake, - no earthquake)
316		37	-
316	45+	47	+
316	96+		-
316	134-		-
316	146-		-
316		225,226	-
316	314+		-
318	21-	37	+
318	31-	47	+
318	94+		-
318	106-		-
318	122+		-
318	138-		-
318	210-	225,226	+
318	221-	225,226	+
318	291+		-
321		37	-
321		47	-
321	218-	225,226	+
344		12	-
344	116-		-
344	164+		-
344		194	-
344	205+		-
348		12	-
348	26+		-
348	107-		-
348	177+		+
348	190-	194	+
348	227-		-
348	241+		-
349	355 (1982)-		+
349	360 (1982)+	12	+
349	211+	194	-
349	271-		-
349	282+		-

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Doering, W. P. and Friedman, I., 1980a, Survey of helium in natural water wells and springs in southwest Montana and vicinity: U.S. Geological Survey Open-File Report 80-181, 42 p.

Doering, W. P. and Friedman, I., 1980b, Survey of helium in natural water wells and springs in southwest Montana and vicinity, Part II-July 1-Dec. 31, 1979: U.S. Geological Survey Open-File Report 80-1257, 18 p.

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U. S. Geological Survey, 1982, Preliminary determination of epicenters, No. 2-83 Feb. 2, 1983, No. 6-83 Mar. 2, 1983, No. 7-83 Mar. 10, 1983, No. 28-83 Aug. 3, 1983, No. 33-83 Sept. 9, 1983: U. S. Geological Survey National Earthquake Information Service.

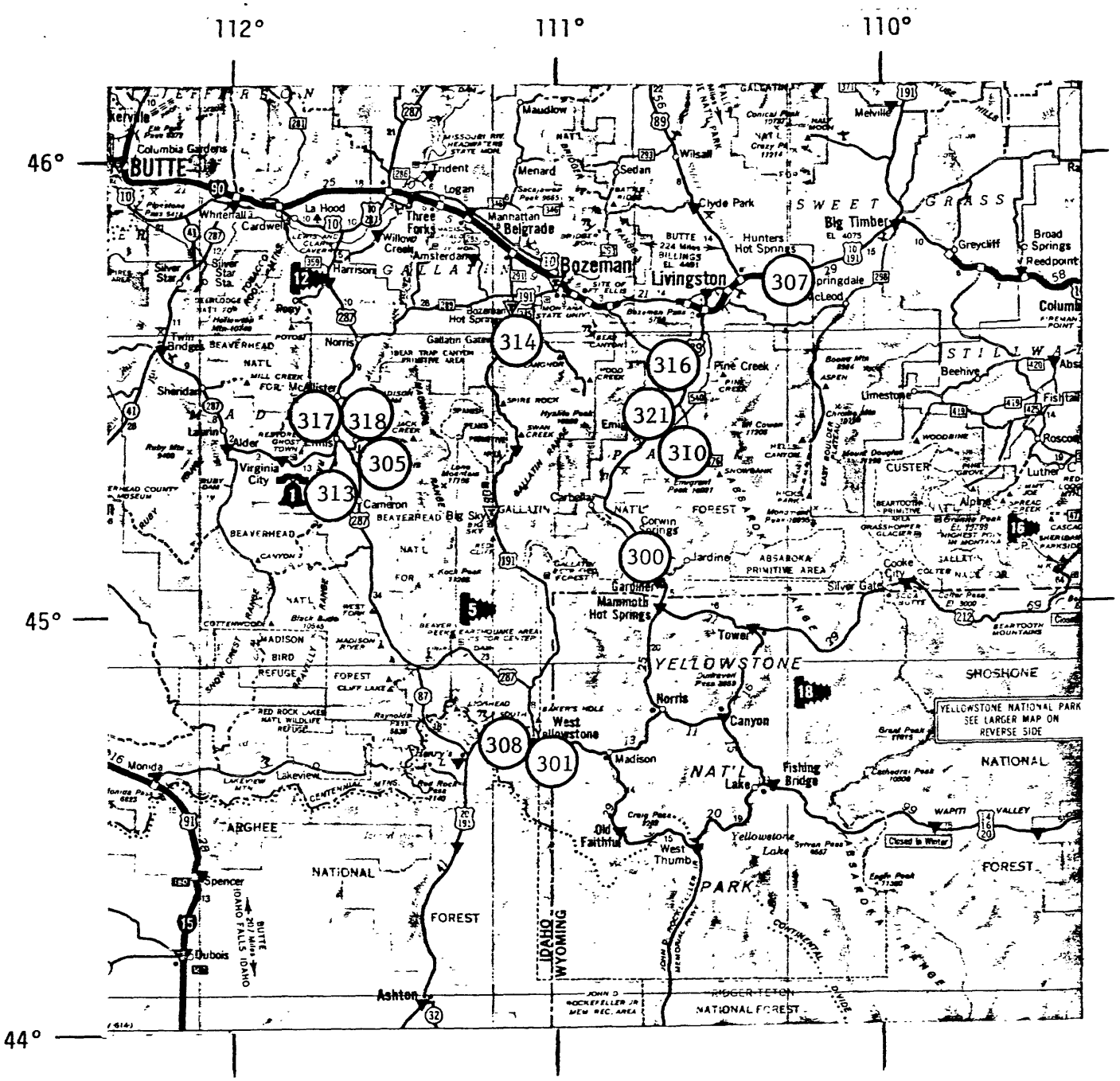

Figure 1.--Helium sampling stations (shown by number) in Montana. Scale approximately 1:1,550,000 (1 inch to 24.6 miles).

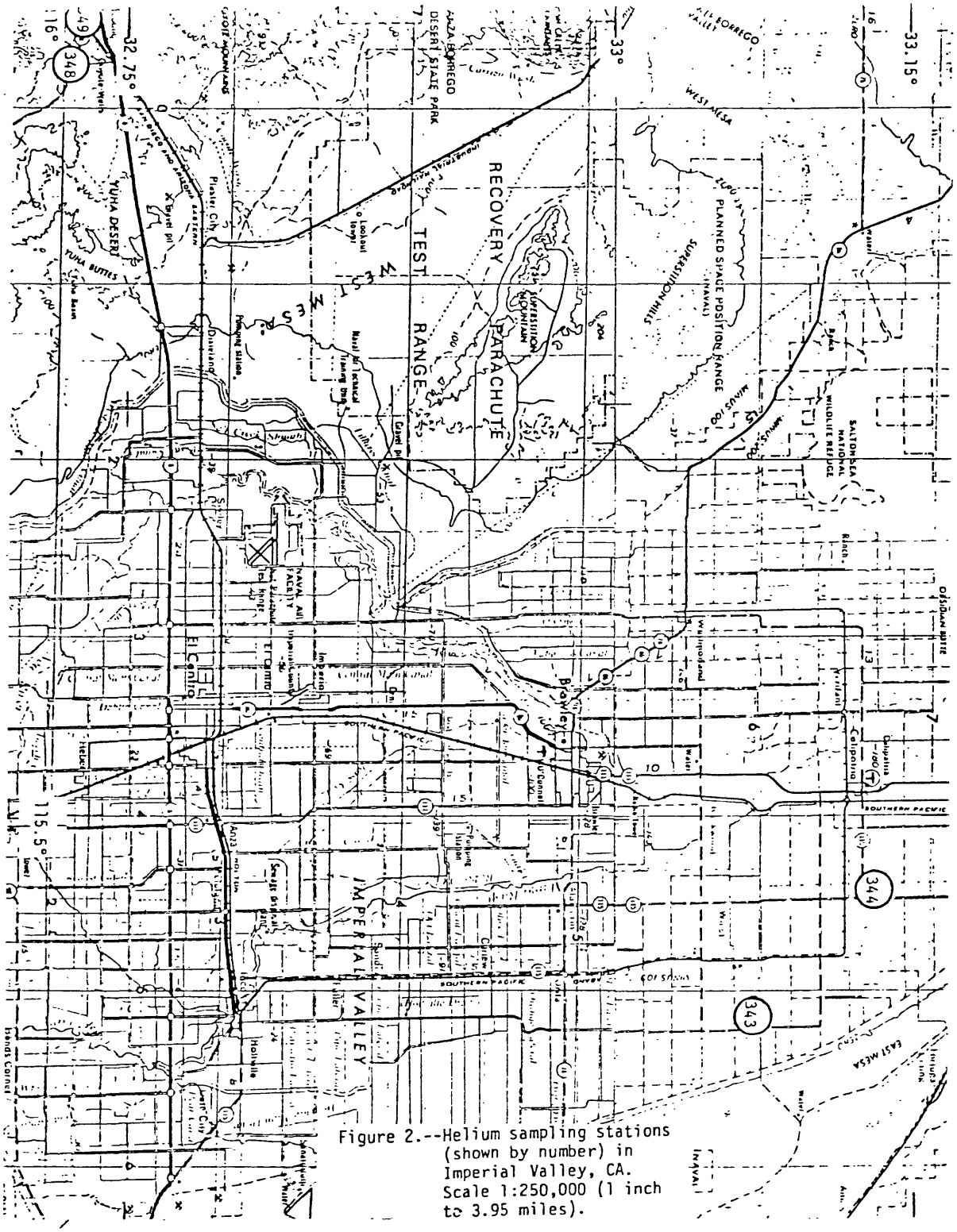

Figure 2.--Helium sampling stations (shown by number) in Imperial Valley, CA. Scale 1:250,000 (1 inch to 3.95 miles).

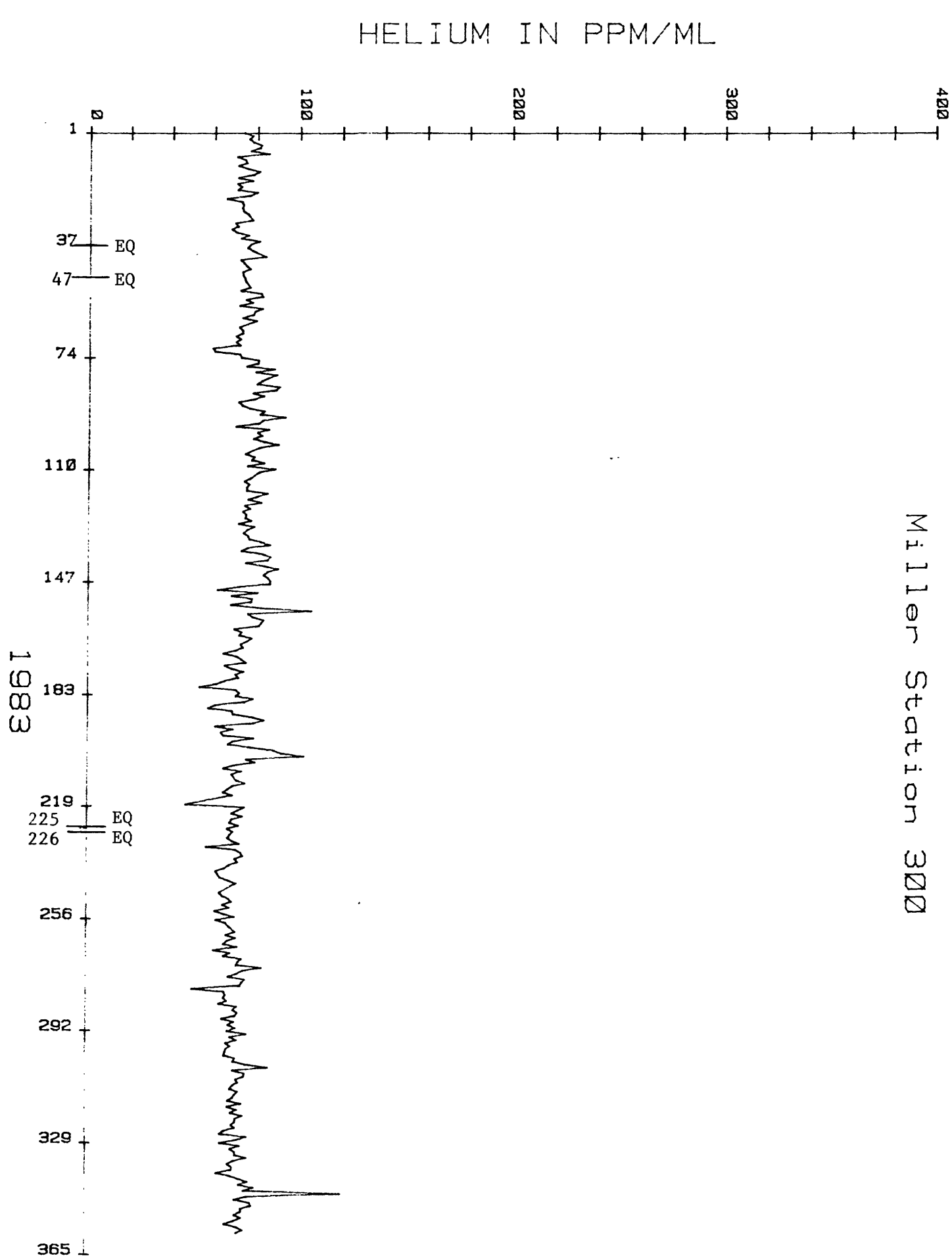

Figure 3.--Helium concentrations in water samples, Gardiner, Montana.

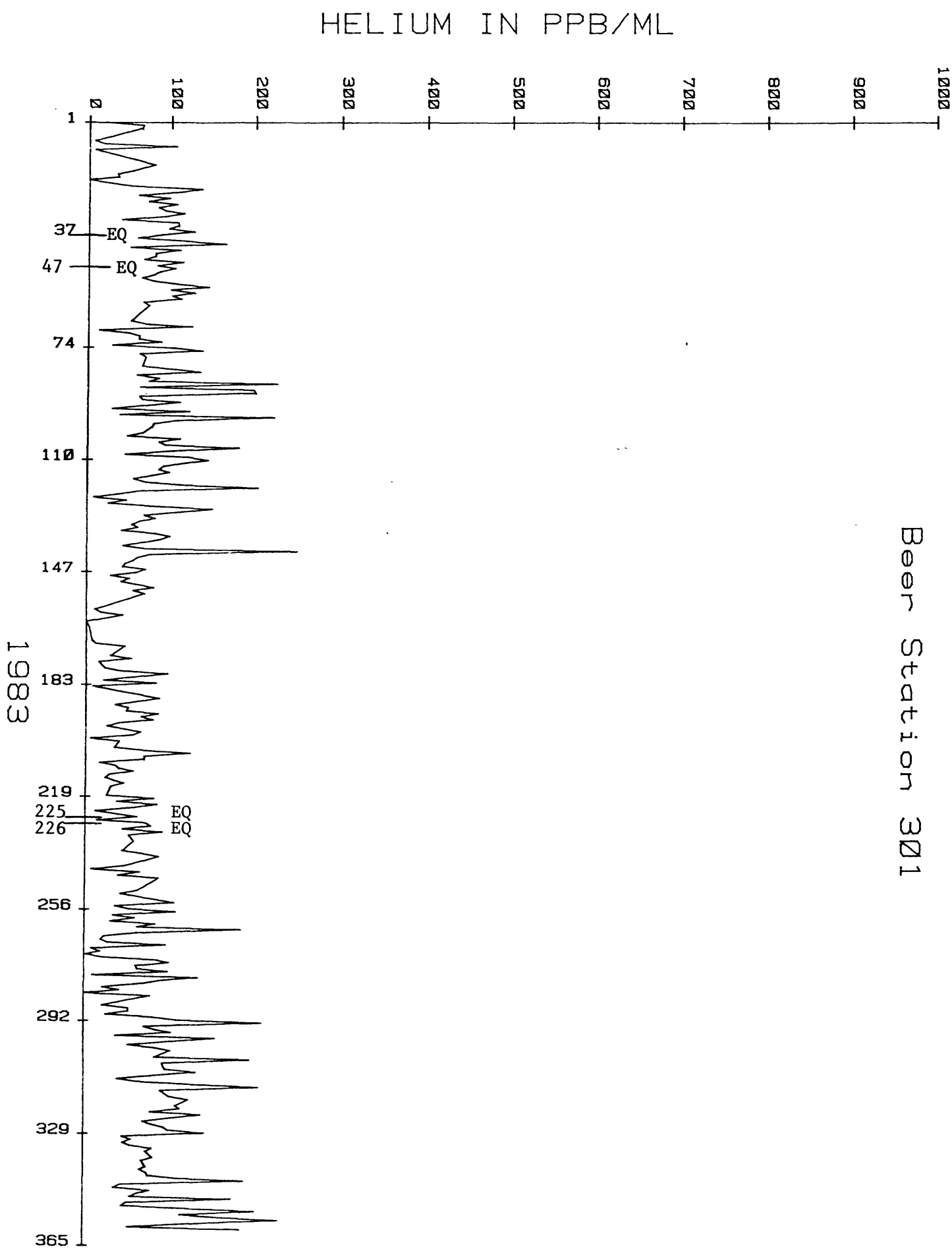

Figure 4.--Helium concentrations in water samples, West Yellowstone, Montana.

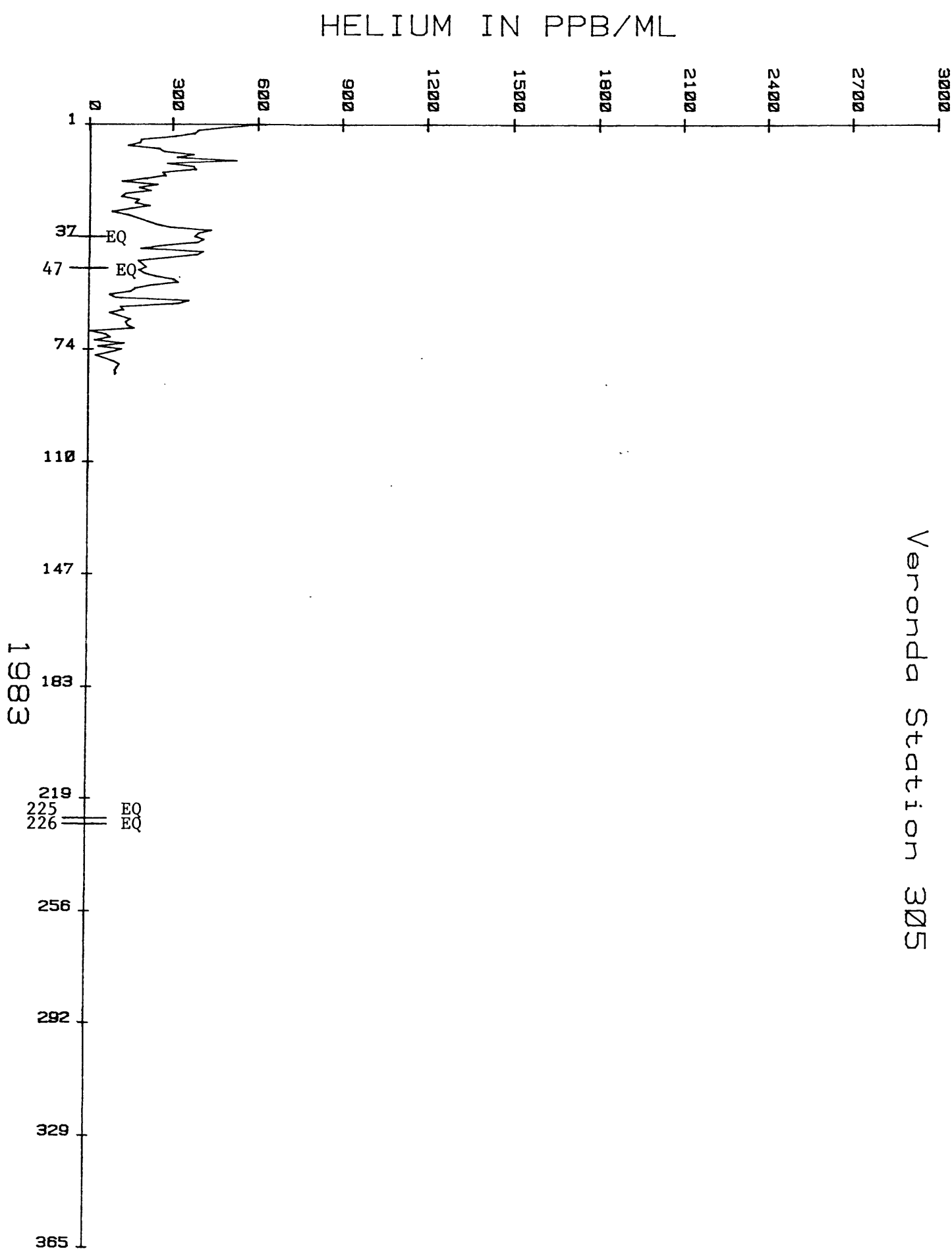

Figure 5.--Helium concentrations in water samples, Ennis, Montana.

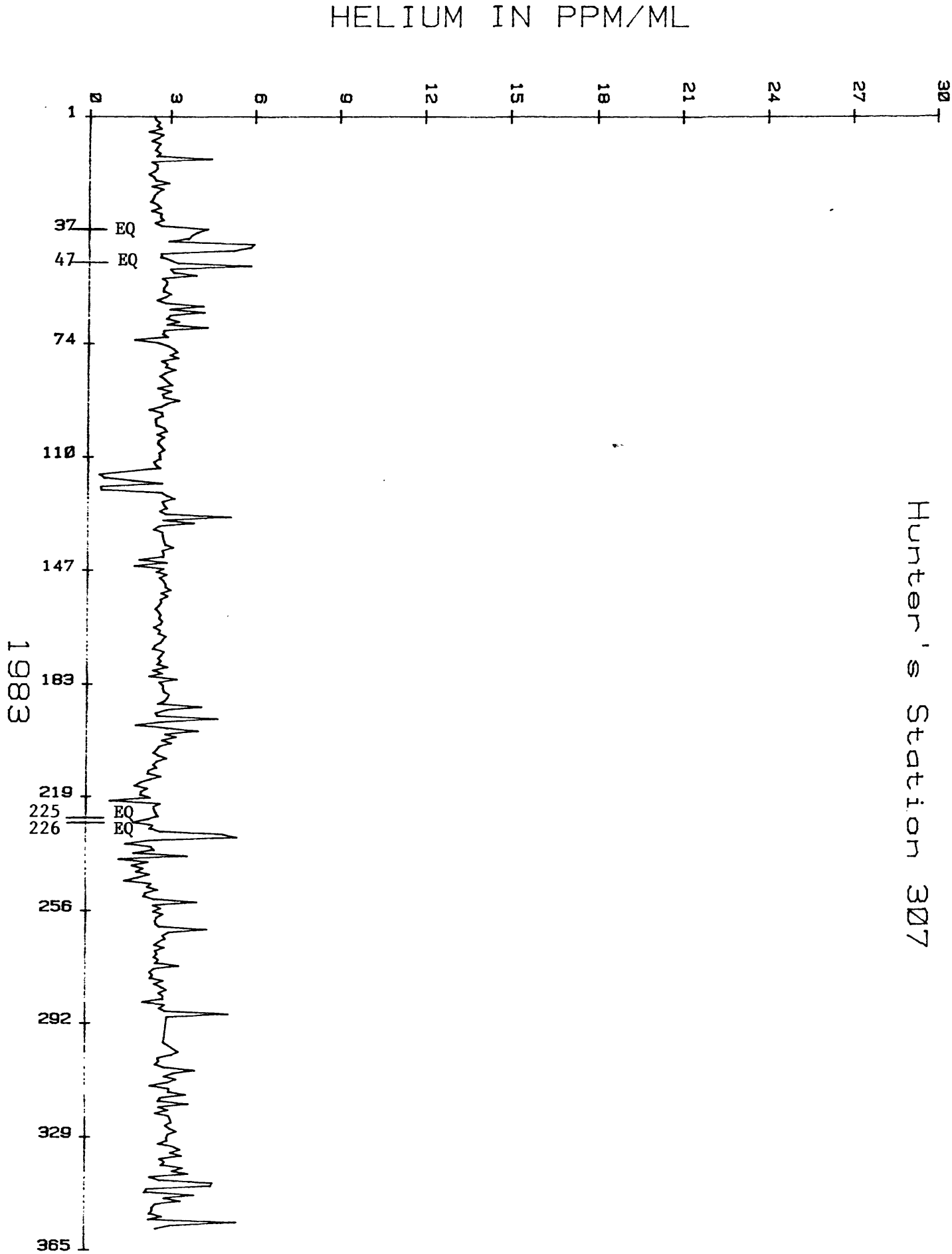

Figure 6.--Helium concentrations in water samples, Springdale, Montana.

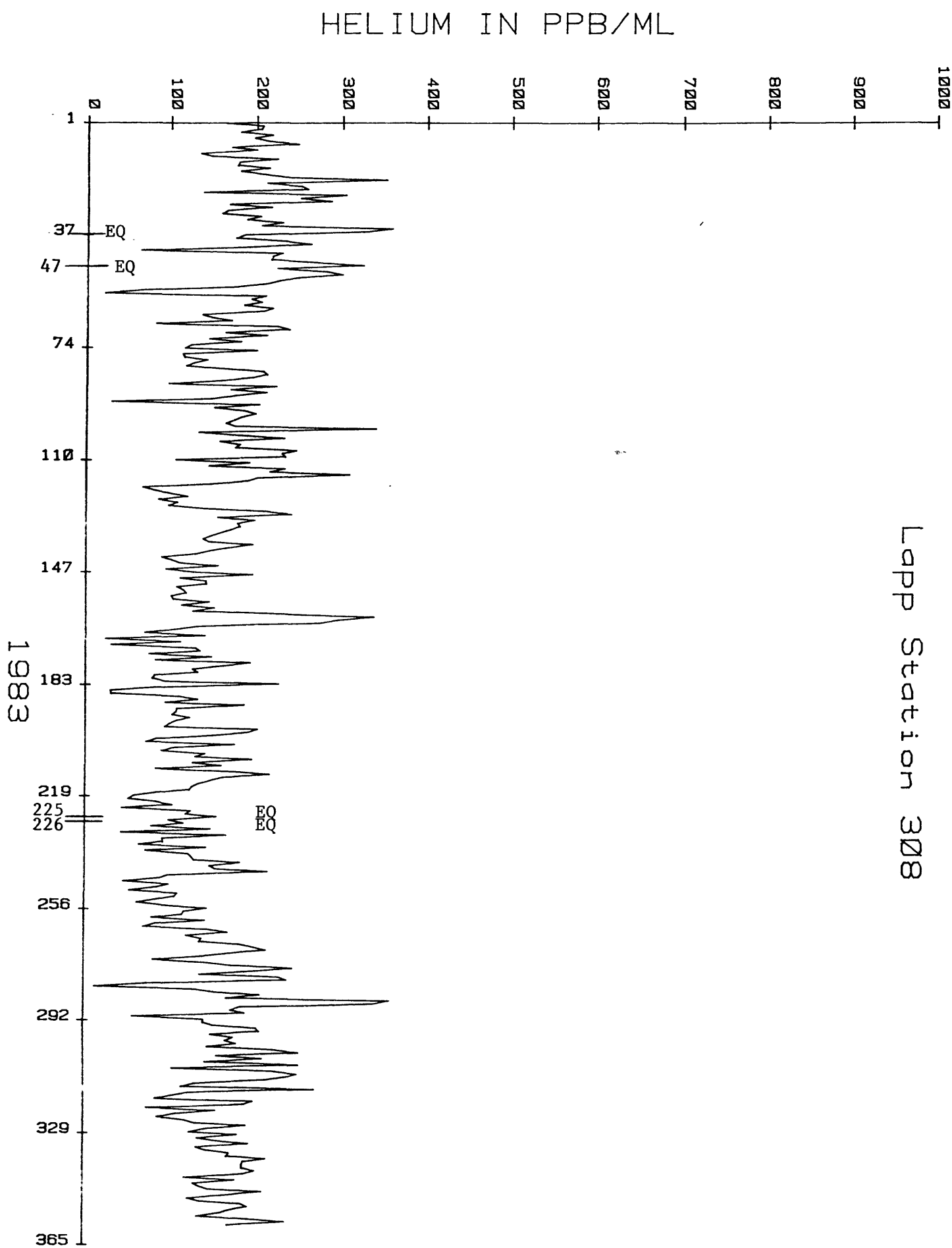

Figure 7.--Helium concentrations in water samples, West Yellowstone, Montana.

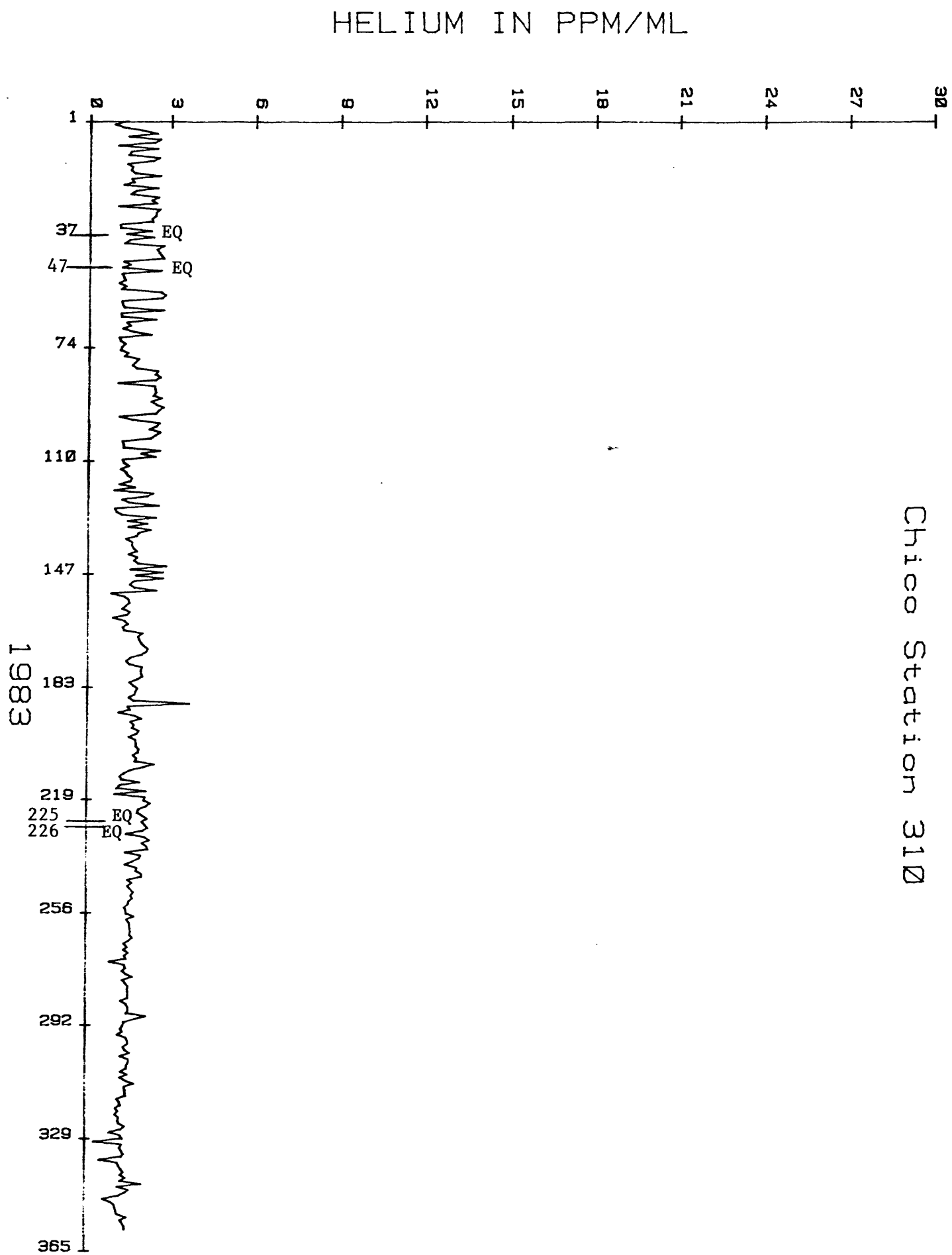

Figure 8.--Helium concentrations in water samples, Pray, Montana.

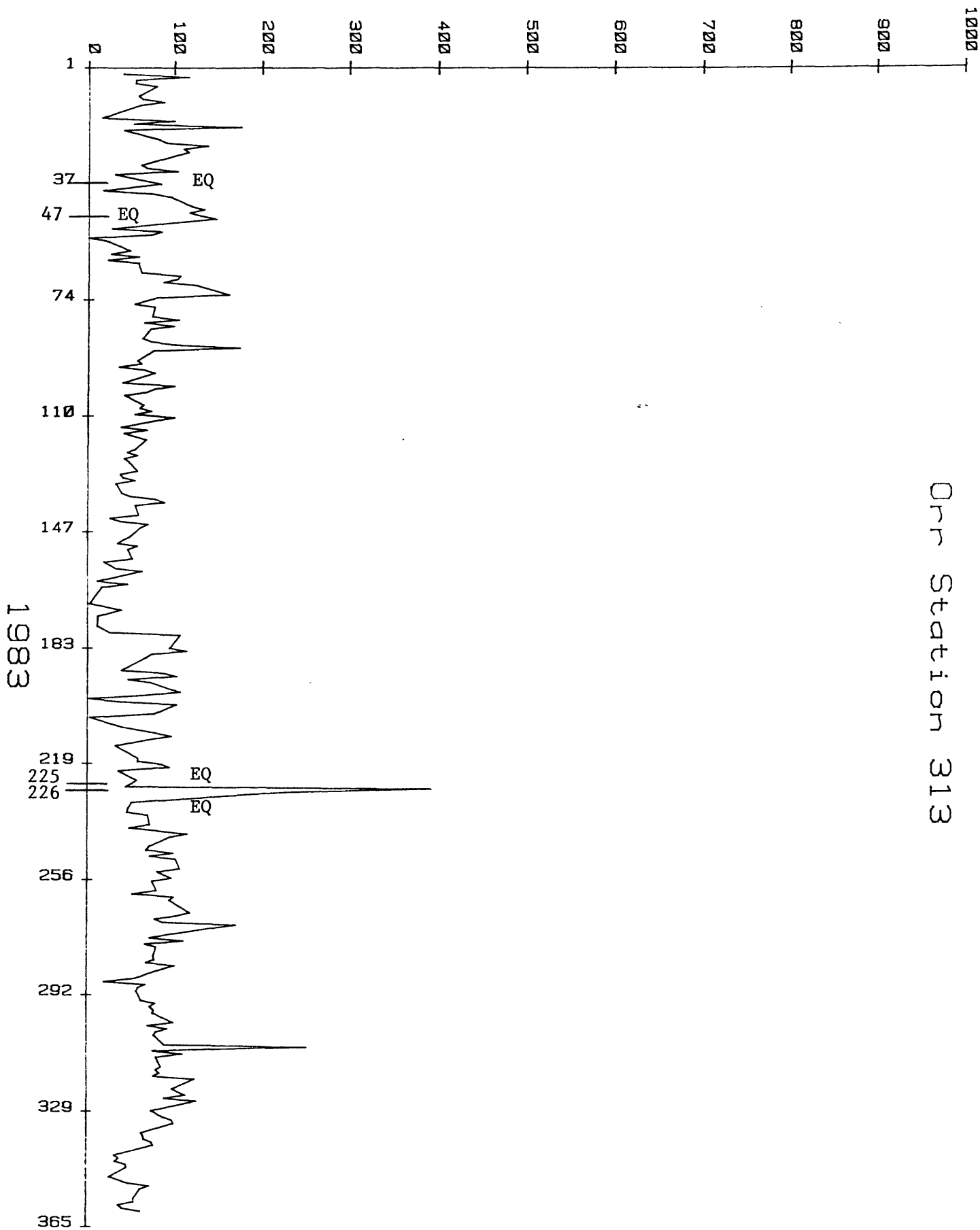

Figure 9.--Helium concentrations in water samples, Ennis, Montana.

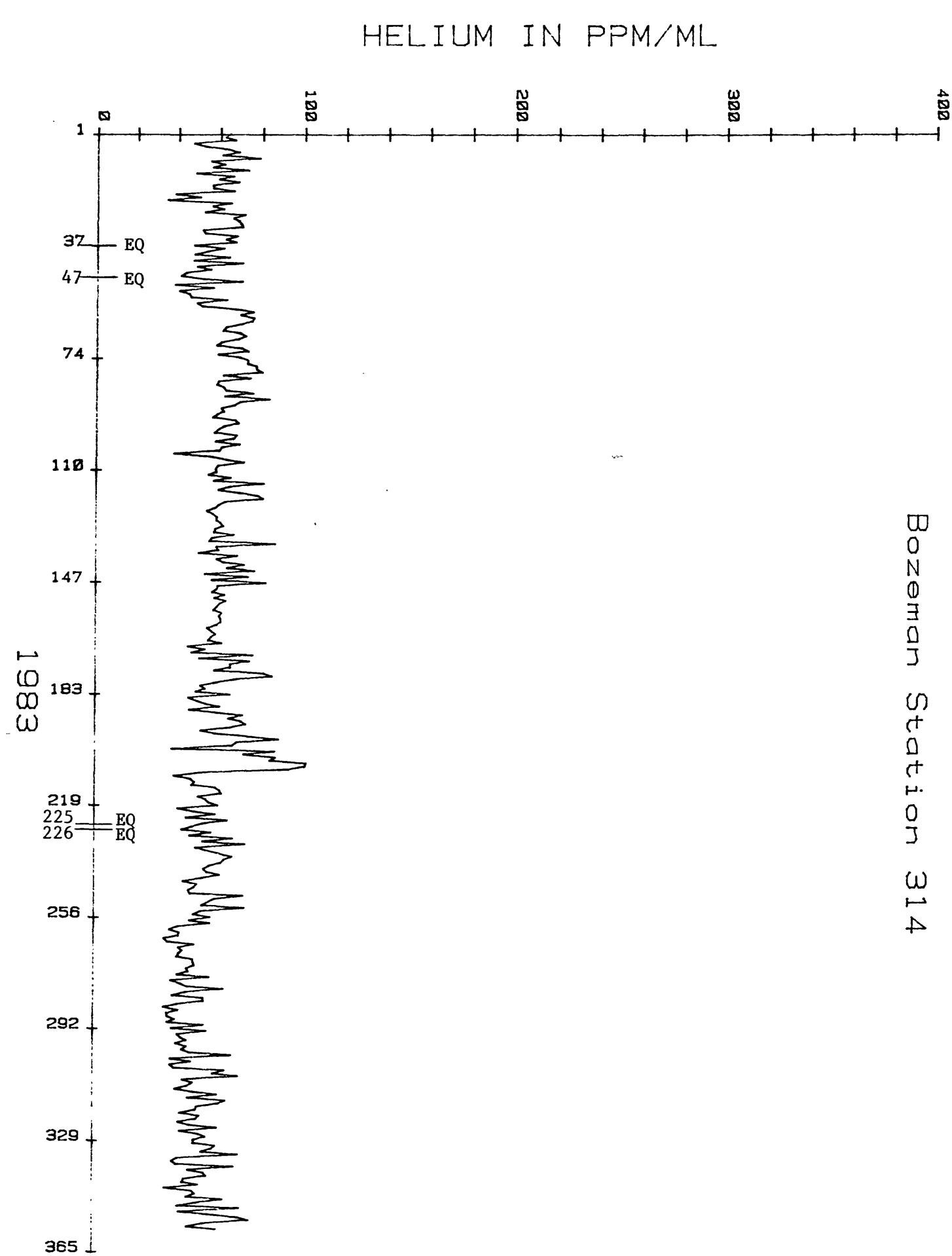

Figure 10.--Helium concentrations in water samples, Bozeman, Montana.

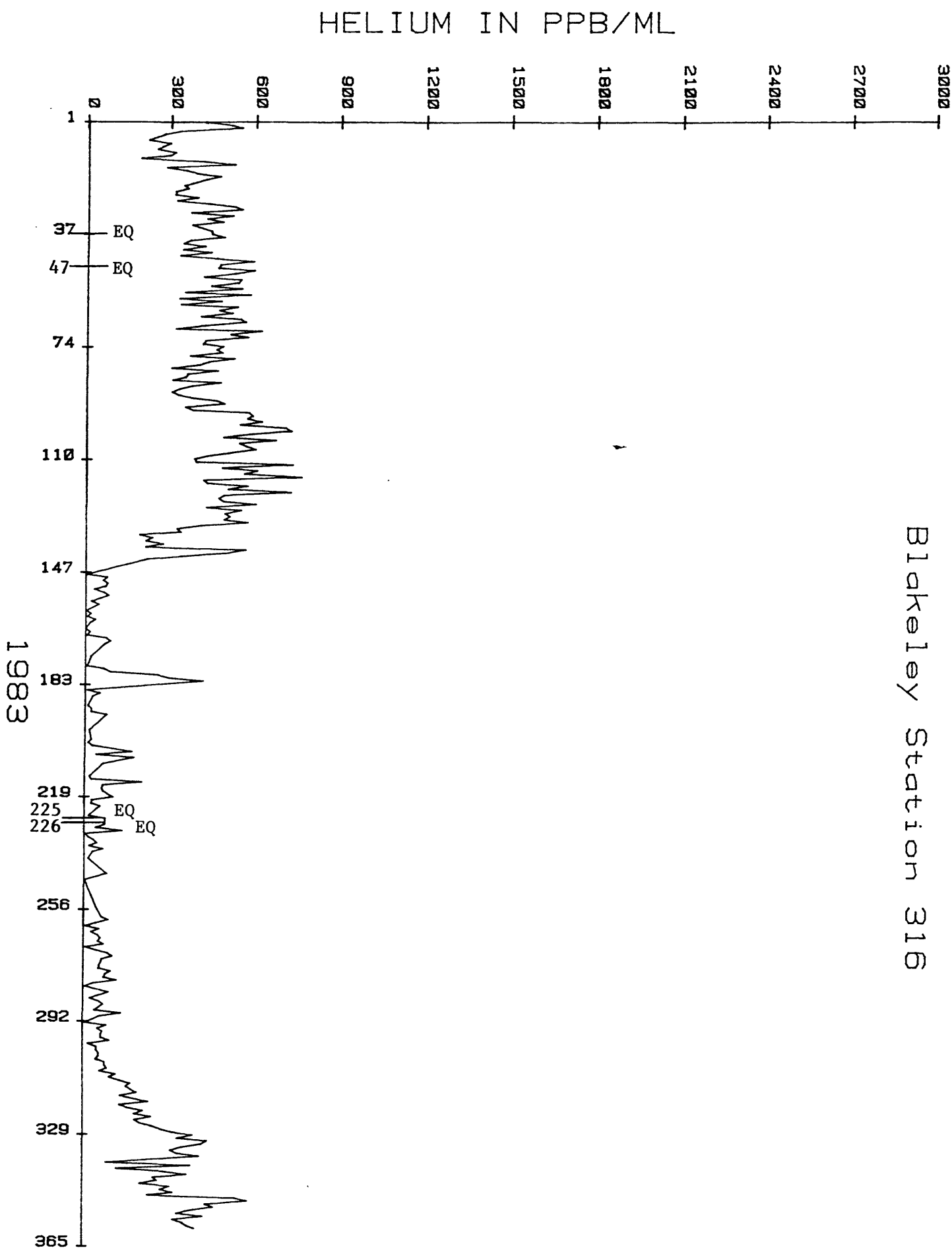

Figure 11.--Helium concentrations in water samples, Livingston, Montana.

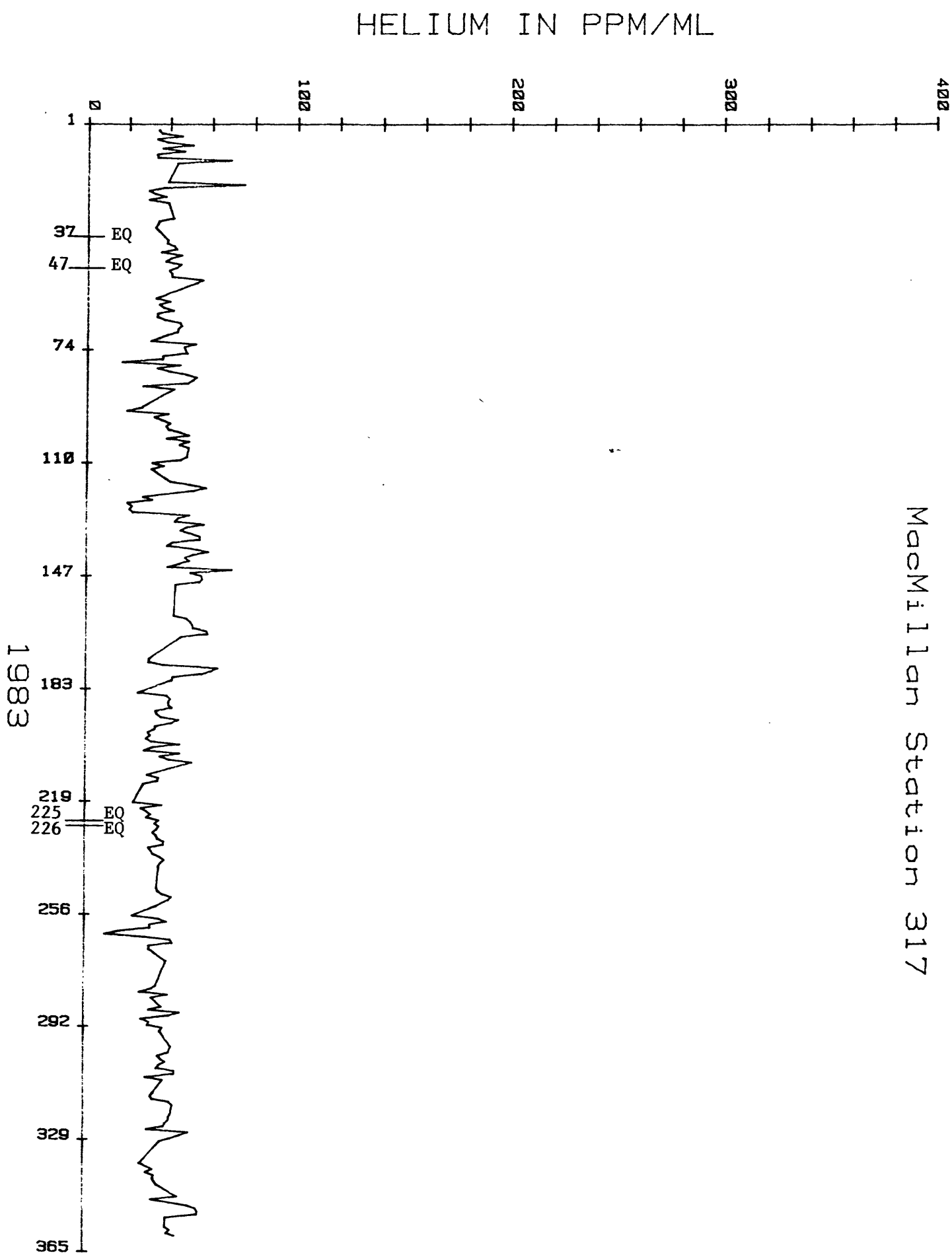

Figure 12.--Helium concentrations in water samples, Ennis, Montana.

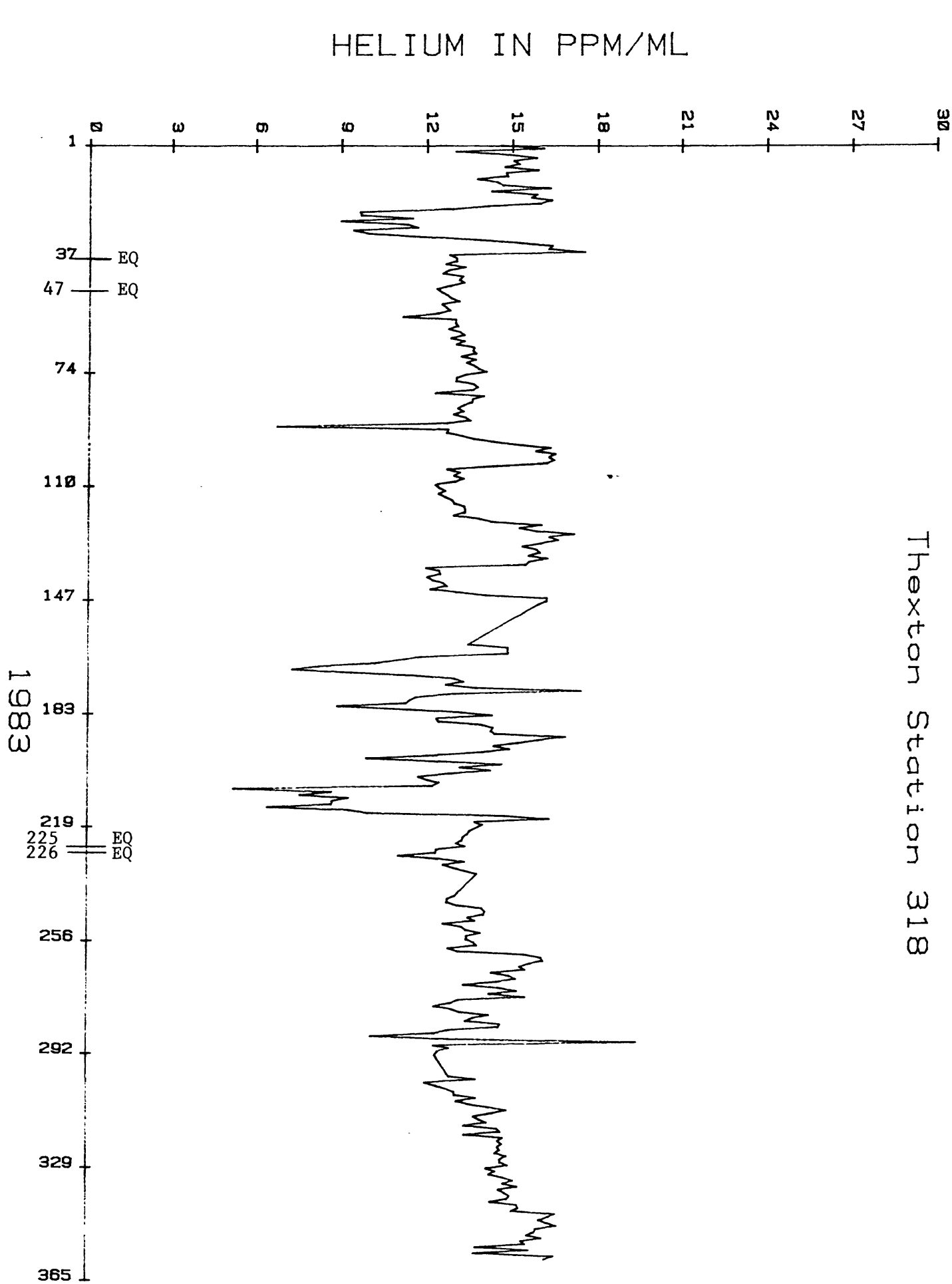

Figure 13.--Helium concentrations in water samples, Ennis, Montana.

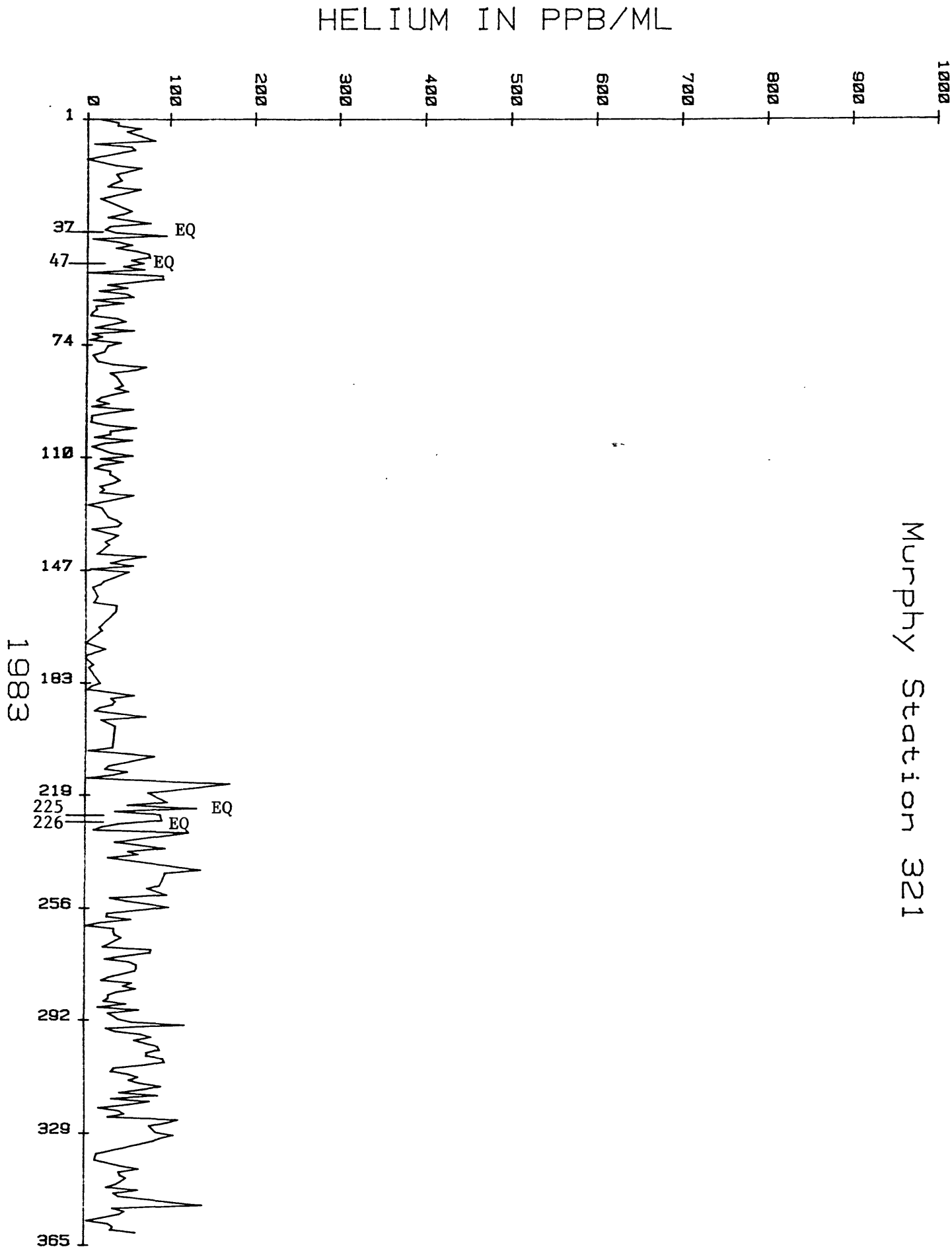

Figure 14.--Helium concentrations in water samples, Emigrant, Montana.

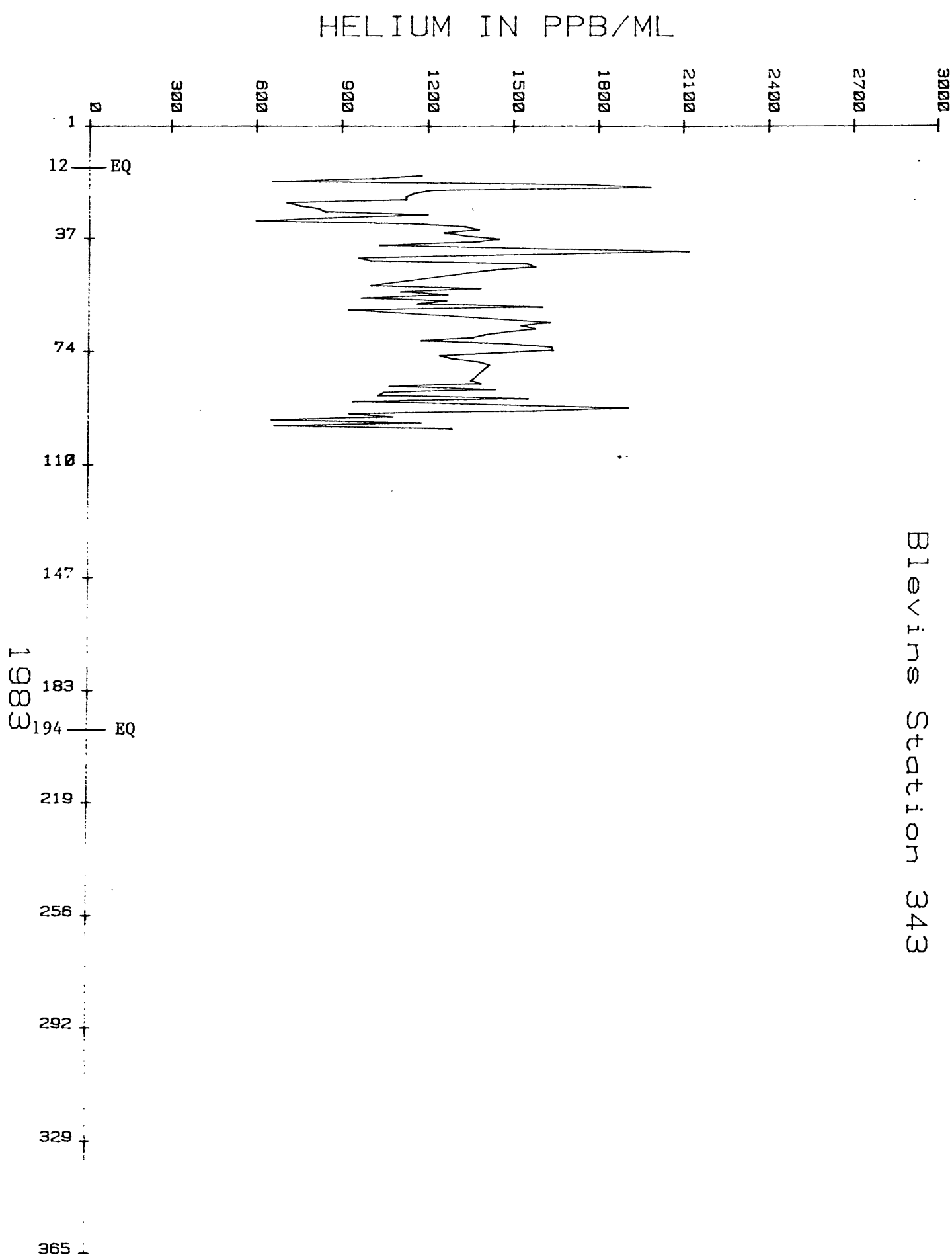

Figure 15.--Helium concentrations in water samples, Brawley, CA.

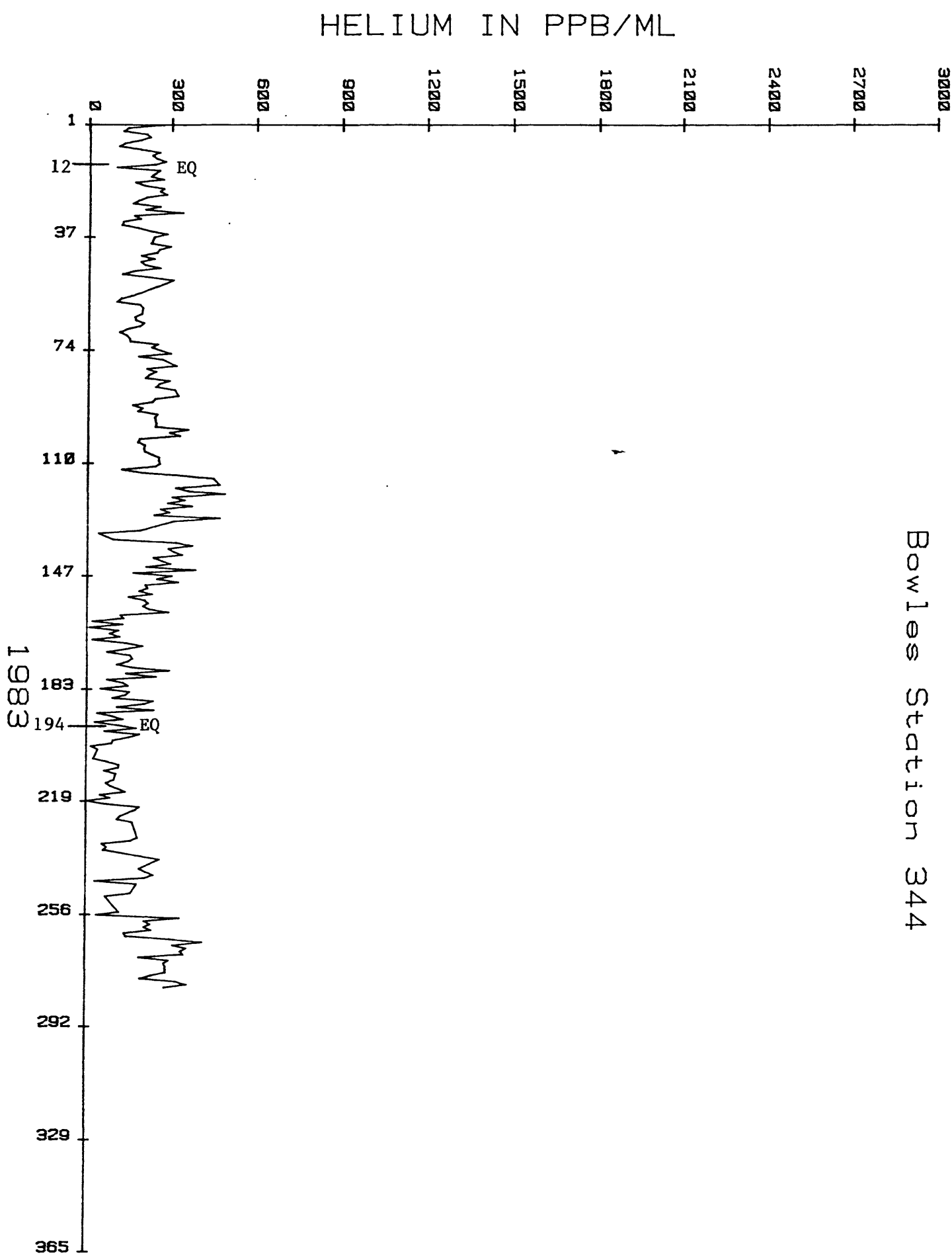

Figure 16.--Helium concentrations in water samples, Calipatria, CA.

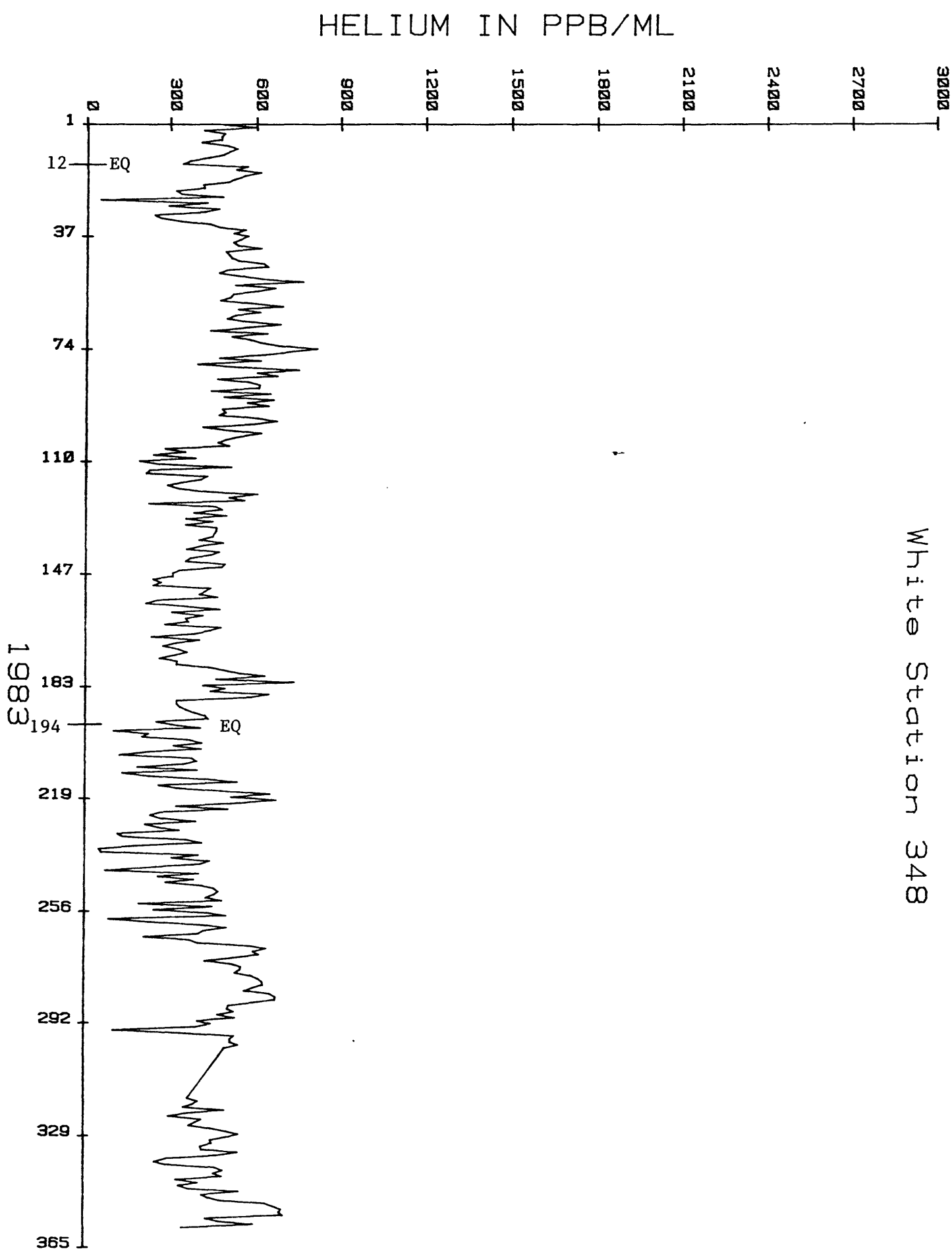

Figure 17.--Helium concentrations in water samples, Ocotillo, CA.

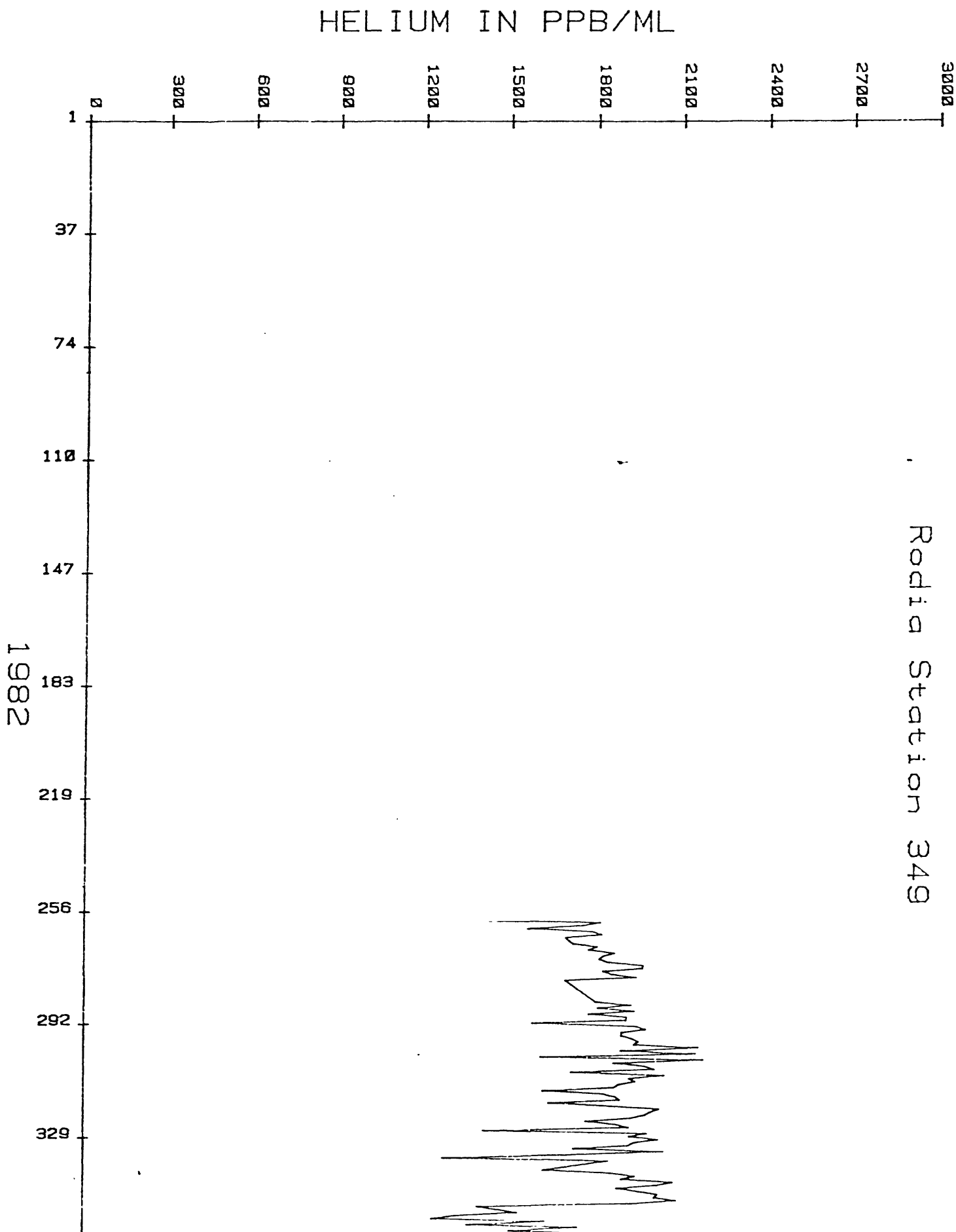

Figure 18.--Helium concentrations in water samples, Ocotillo, CA.

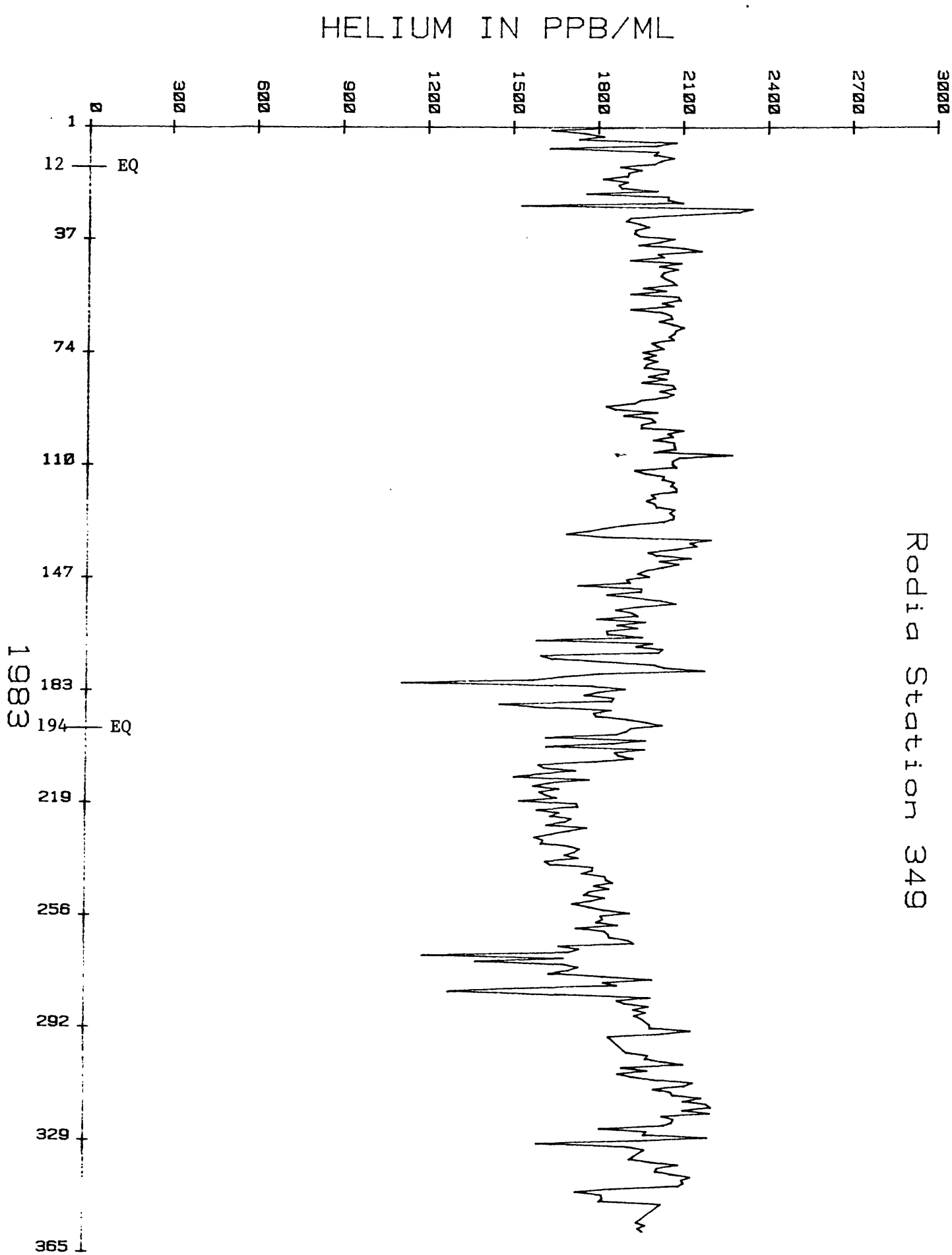

Figure 19.--Helium concentrations in water samples, Ocotillo, CA.

JULIAN DATE CALENDAR

(PERPETUAL)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

Figure 20.--Chart showing correlation of Julian and Gregorian calendar.