UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Survey of helium in natural water wells and springs in southwest Montana and vicinity

By

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Open-File Report 80-131

Survey of helium in natural water wells and springs
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A relation between helium concentrations in underground water and earthquakes in locations subject to severe earthquakes has been discovered. This study monitored the helium concentration of ground water to determine whether it may be possible to predict an earthquake days in advance of its occurrence.

Since the area around Hebgen Lake, Montana, is seismically active, it was considered a good location to test this method of earthquake prediction. A number of water wells and springs were selected for periodic sampling (fig. 1). The selection was made on the basis of several factors, including proximity to the epicenter of the Hebgen Lake earthquakes, depth of the well, helium concentration in the well or spring, and the availability of volunteer sample collectors.

The volunteers agreed to mail into our laboratories the water samples they collected daily or bi-daily. The equipment they were provided to collect the samples consisted of a water faucet to connect to a garden hose and a rubber septum, which permits a hypodermic needle to be inserted into it to withdraw water into a 10 ml plastic hypodermic syringe. A line inscribed on the syringe indicates a volume of 9 ml, the amount to be collected each day. After filling the syringe to the mark, the water was immediately transferred to an evacuated glass tube sealed with a butyl rubber stopper. These tubes (originally manufactured for the collection of human blood samples) are received evacuated to about 1/5 atmosphere. After the sample was transferred from the syringe to the glass tube, the small hole in the stopper was covered with silicone rubber sealant to prevent possible loss of gas. The date of collection was then written on the tube. When five such tubes were filled, they were placed in a molded styrofoam box, inserted into a cardboard sleeve and sent to the laboratory for analysis.

Table 1 is a description of each spring or well sampled for this report.

Table 1 -- Localities of helium sampling stations

Station No.	Station Name	Address	Comments
300	Miller	Dick Miller River Route Box 17 Gardiner, Mont. 59030	58.5 m (192 ft) deep; well pump at 50.3 m (165 ft) pumped continuously at 7.6 lpm (2 gpm); water temp. 67°. This well is about 300 m from a small warm spring, and 1000 m from La Duke Hot Springs, a large hot spring. The water is high in fluorine and iron.
301	Beer	U.S.G.S. Box 1049 West Yellowstone,Mont. 59758	This well is 61 m (200 ft) deep and is a water source for service facility at Yellowstone National Park entrance.
303 304	Ear Spg. Scissors spg.	Margaret Short Old Faithful Visitor's Center, Yellowstone National Park, Wyoming 82190	Two hot springs near Old Faithful geyser.
305	McAtee	Leonard McAtee Cameron, Mont. 59720	61 m (200 ft) deep; domestic water supply.
306	Beartrap	Mike Zankowsky P.O. Box 24 Norris, Mont. 59745	Large hot pool used for bathing.
308	Lapp	Allen L. Lapp Box 503 West Yellowstone Montana 59758	Town well, 67.7 m (222 ft) deep; cased to 45.7 m (150 ft).
309	Povah	Pat Povah Deep Well Ranch West Yellowstone Montana 59758	274 m (900 ft) well, artesian flow with 1.8 m (6 ft) head.
310	Chico	Eve Art Chico Hot Springs Pray, Mont. 59065	Hot spring.
312	Bathtub	Paul Miller River Route Box 17 Gardiner, Mont. 59030	Large warm pool at top of Mammoth Hot Springs, Yellowstone National Park.

The water samples were analyzed for helium in the laboratory at the Denver Federal Center on a Dupont Instruments model 120 SSA mass spectrometer.[1/] A liquid-nitrogen-cooled charcoal trap in the inlet system of the mass spectrometer prevents most other gases and water vapor from entering the spectrometer but allows the helium to pass through. The glass blood sample tubes have a volume of 13 milliliters; the ullage space of about four milliliters above the water sample contains 2.6 ml of air (NTP) as well as the helium released from the water sample. The ullage gas was removed into an empty glass hypodermic syringe by displacement with water that had been in equilibrium with air. The water was introduced into the glass sample container through another needle connected to a bottle of water under slight air pressure. The gas in the glass syringe was admitted to the spectrometer through the forementioned cold trap. The output signal from the spectrometer was recorded on a strip chart recorder. This signal was compared to the recording produced by a reference gas with a known amount of helium. The reference gas was run first on the spectrometer, then an ambient air sample was run, followed by an unknown water sample, and then another air sample. This series of analysis takes about three minutes. After five water and air samples were run, the reference gas was re-analyzed. The difference between the reference gas and each unknown sample peak height and that of the ambient air was measured. By comparing the reading of each unknown sample to the reading of the reference gas the concentration of each unknown sample was calculated and expressed in ppb (parts per billion) or ppm (parts per million) above the concentration of ambient air.

Figure 1 is a map showing the locations of the helium sampling stations and seismic stations.

[1/] The use of a commercial trade name is for descriptive purposes only and does not constitute endorsement of the product by the U.S. Geological Survey.

Graphs for the 10 stations accompany this report; they show the helium concentration expressed as ppm or ppb helium above that of air (5.2 ppm) per ml of water, as a function of collection date for each station. Julian-calendar dates as shown on figs. 2-36 can be converted to Gregorian dates (see fig. 37). Each graph covers a period of six months. Most stations show data for samples collected beginning in September, 1977 and continue to July, 1979. Where there are straight lines between more than consecutive days there was no data for those days. With the exception of station 300, the data does not show any large deviation. Most stations have a helium content of 400 ppb/ml or less. Station 306 varies from 600 to 2000 ppb/ml; it is difficult to get a satisfactory sample from this hot spring and we have discontinued collections at this site.

The graphs for station 300 have marks along the date line which indicate when an earthquake of 3.0 magnitude or larger on the Richter scale occurred and the letter corresponding to the location of the seismic station shown on the map closest to the epicenter. The most intense earthquake during this period had an intensity of 4.7 and occurred October 19, 1977. Data are plotted on the first graph several months preceeding and following the quake. Note that the helium values fell to almost zero about 17 days preceeding the quake, and rose to very high values just after the earthquake. The two years that followed this earthquake have been seismically quiet. However, beginning on March 15, 1979, the graph for station 300 shows a sudden, large helium increase with large fluctuations. These fluctuations may be due to sample collection problems. At this time we have no explanation for the higher average helium content.

This is the first report of information from an ongoing project to test the validity of using changes in the helium content of ground water as a precursor of major earthquakes. The majority of this first data shows no

great variations; there were about 13 earthquakes of magnitude 3 or greater, and only one of 4.7 magnitude in the area under study during this reporting period.

Acknowledgements

Earthquake data was provided by Mitchel Pitt (written commun., December, 1978 and September, 1979). We are also indebted to our volunteer collectors who provided the samples.

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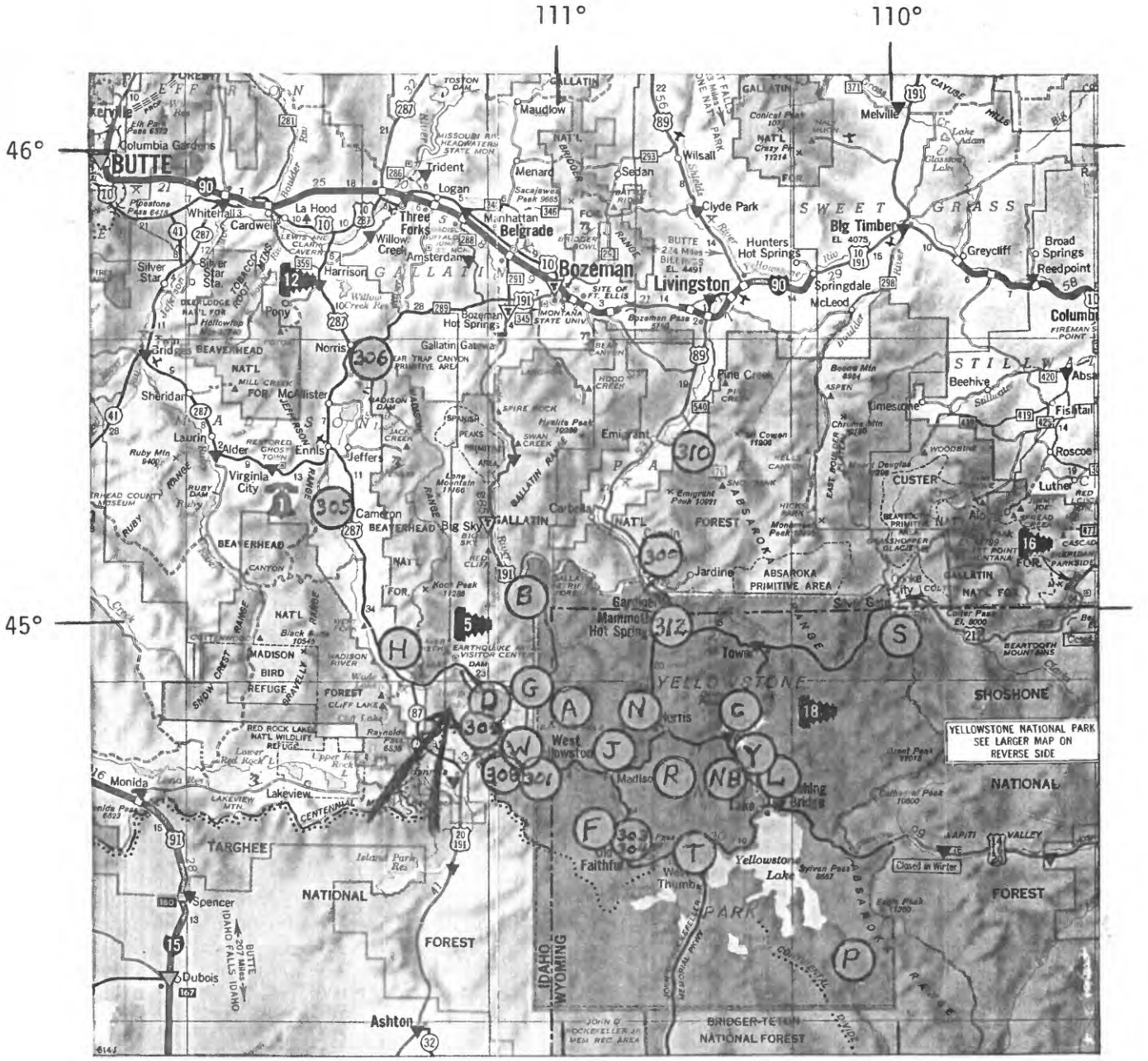


Figure 1. Helium sampling stations (shown by number) and seismic stations (shown by letter). Seismic stations shown but not discussed herein may be referenced in future reports in this project. Arrow shows Hebgen Lake. Scale approximately 1:1,550,000 (1 in to 24.6 mi).

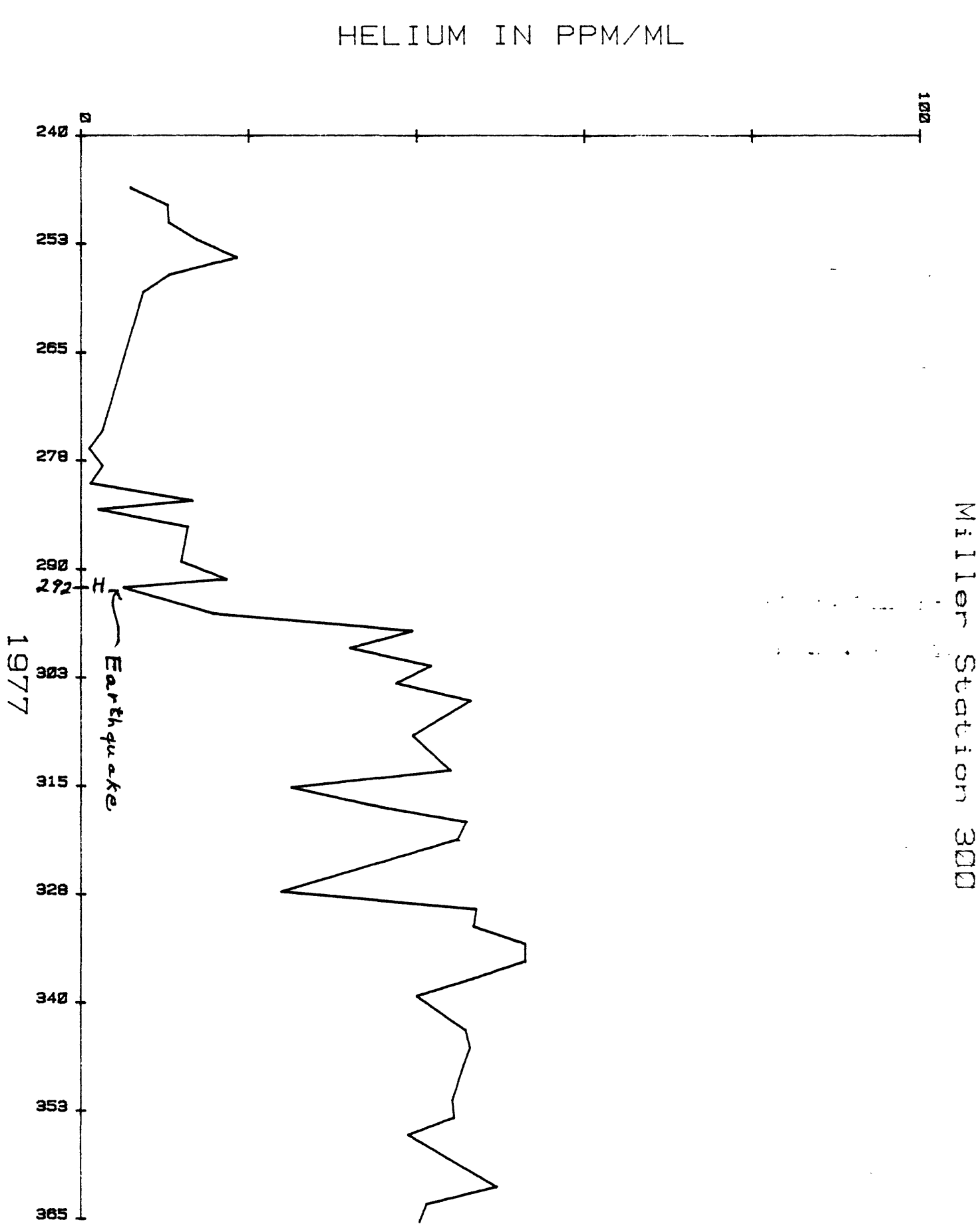


Figure 2.--Helium concentrations in water samples, Gardiner, Montana, September through December, 1977.

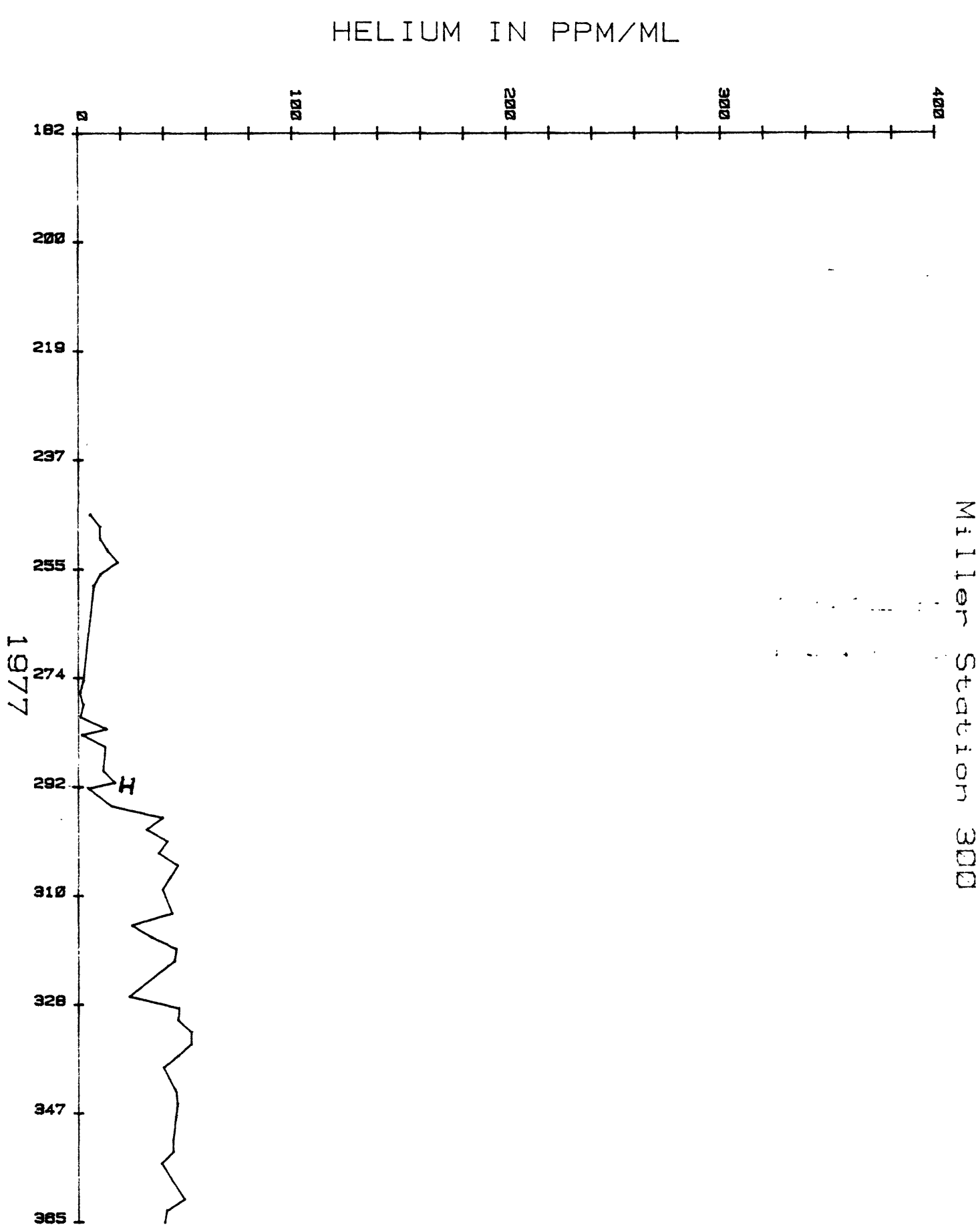


Figure 3.--Helium concentrations in water samples, Gardiner, Montana, July through December, 1977.

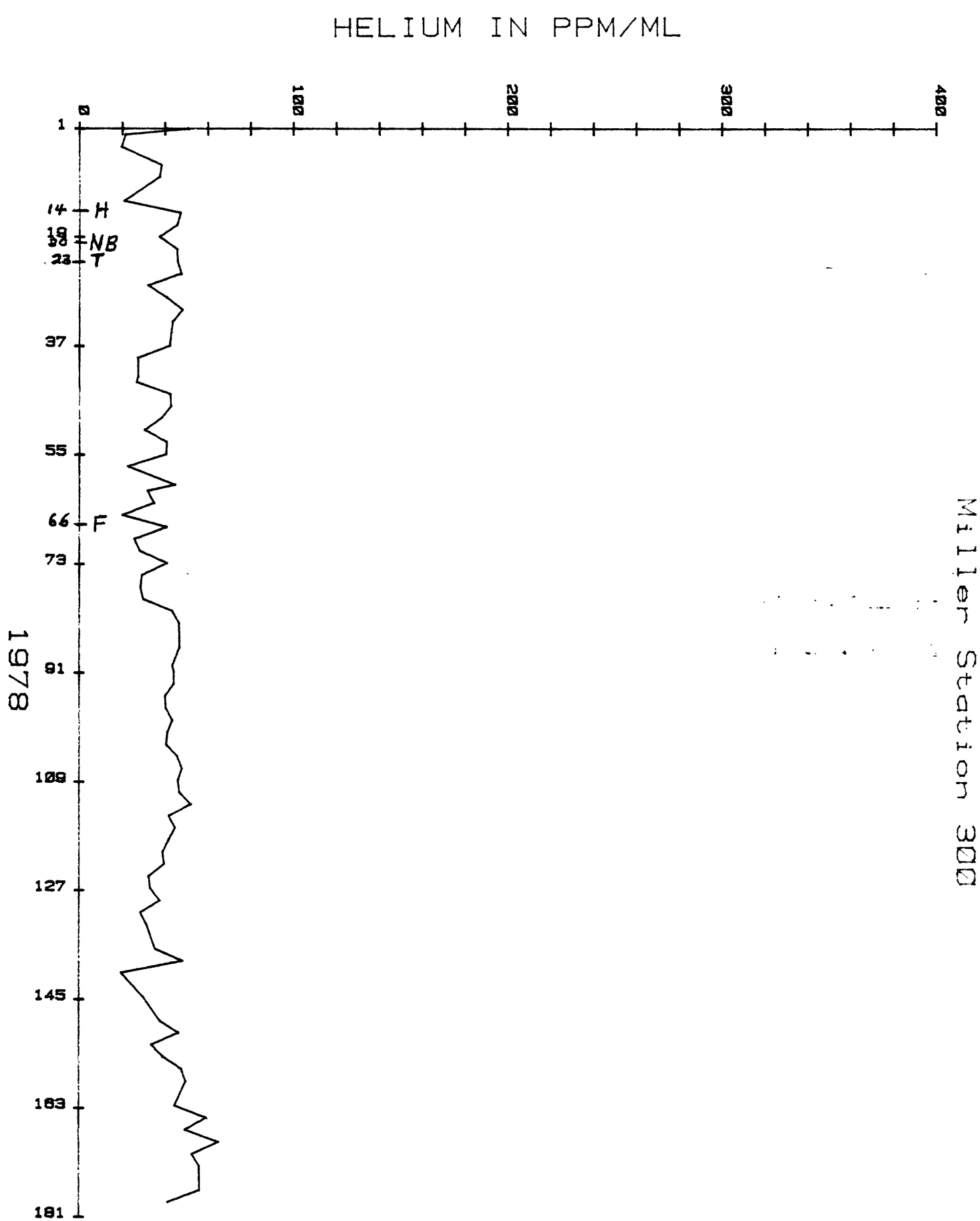


Figure 4.--Helium concentrations in water samples, Gardiner, Montana, January through June, 1978.

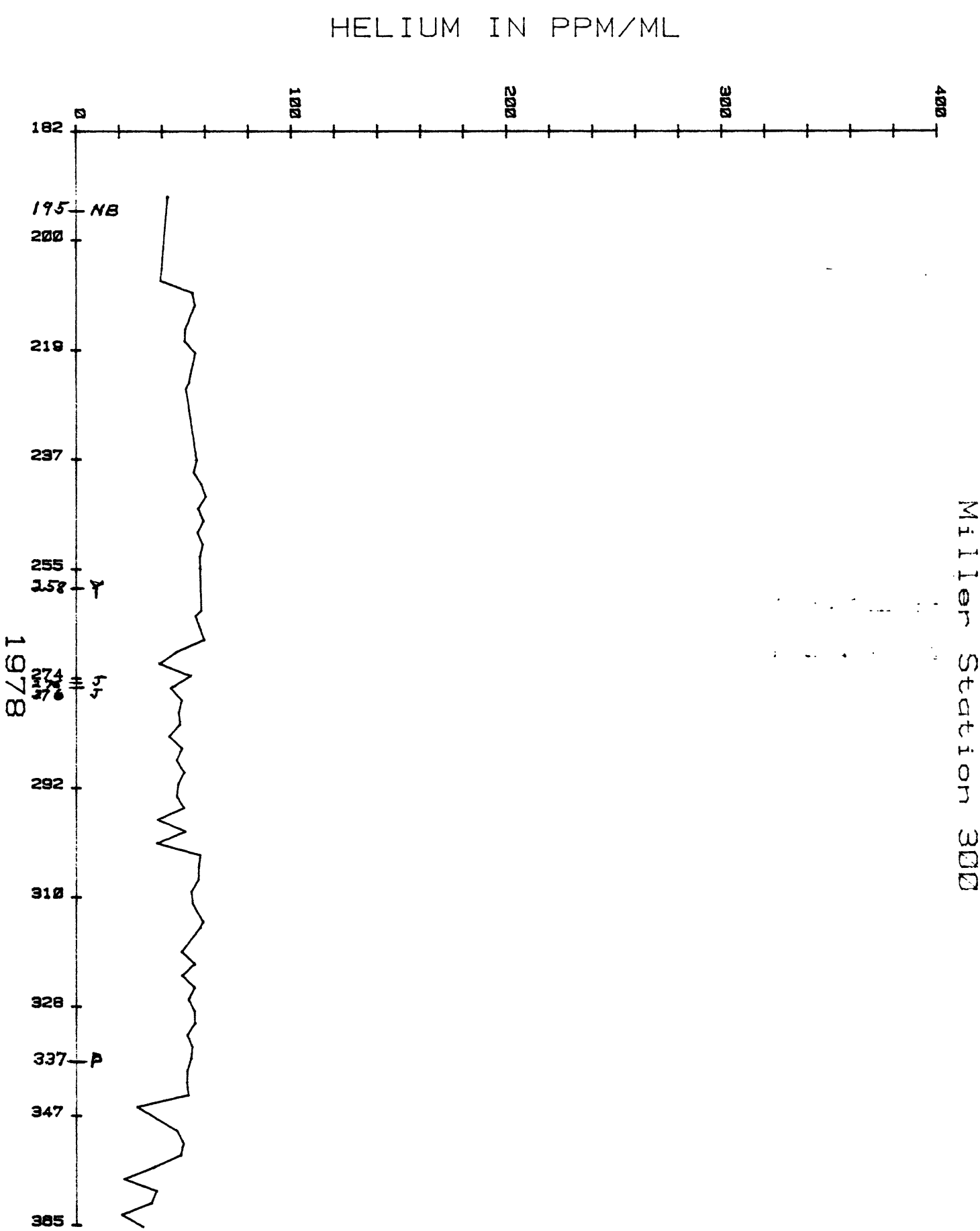


Figure 5.--Helium concentrations in water samples, Gardiner, Montana, July through December, 1978.

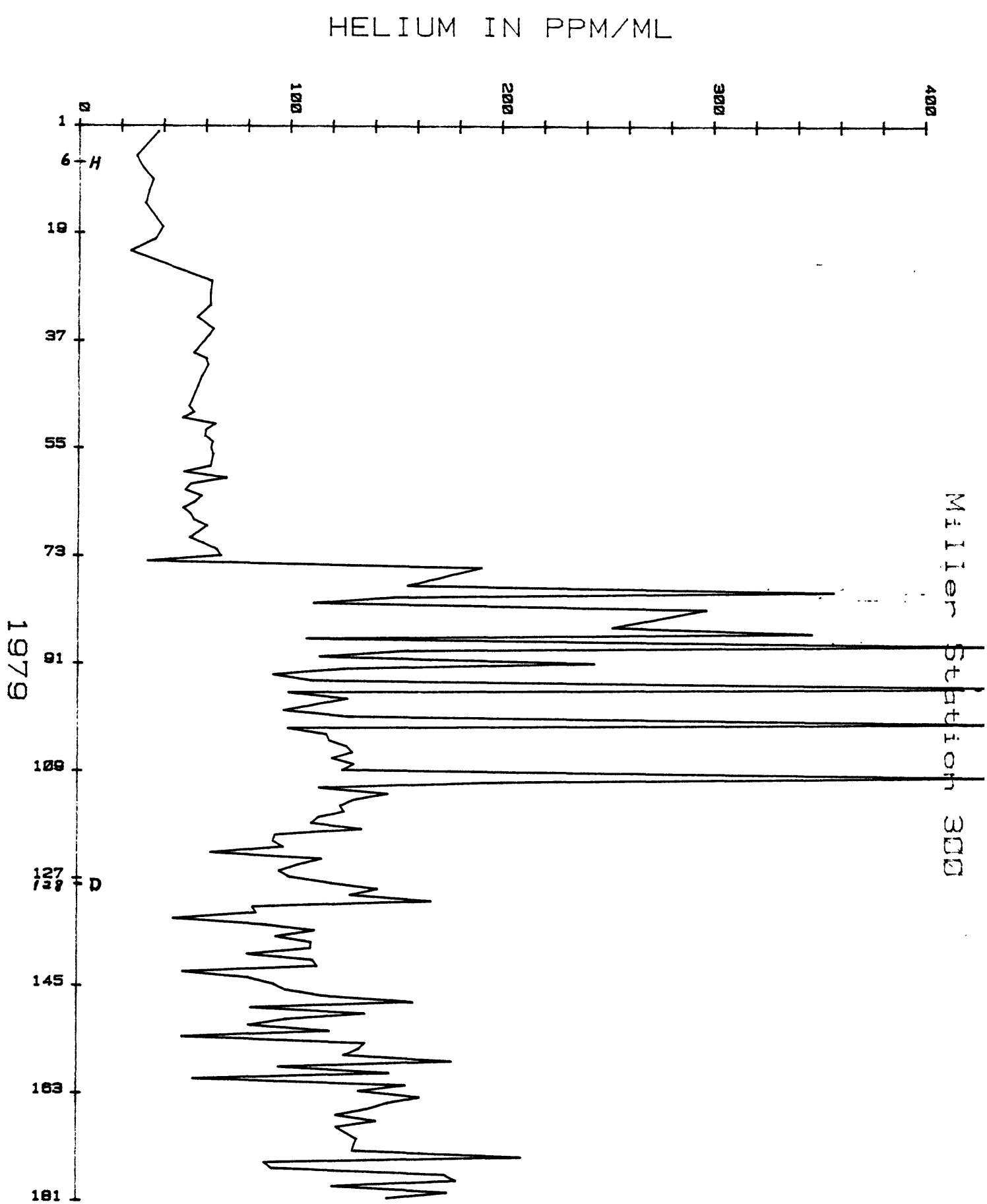


Figure 6.--Helium concentrations in water samples, Gardiner, Montana, January through June, 1979.

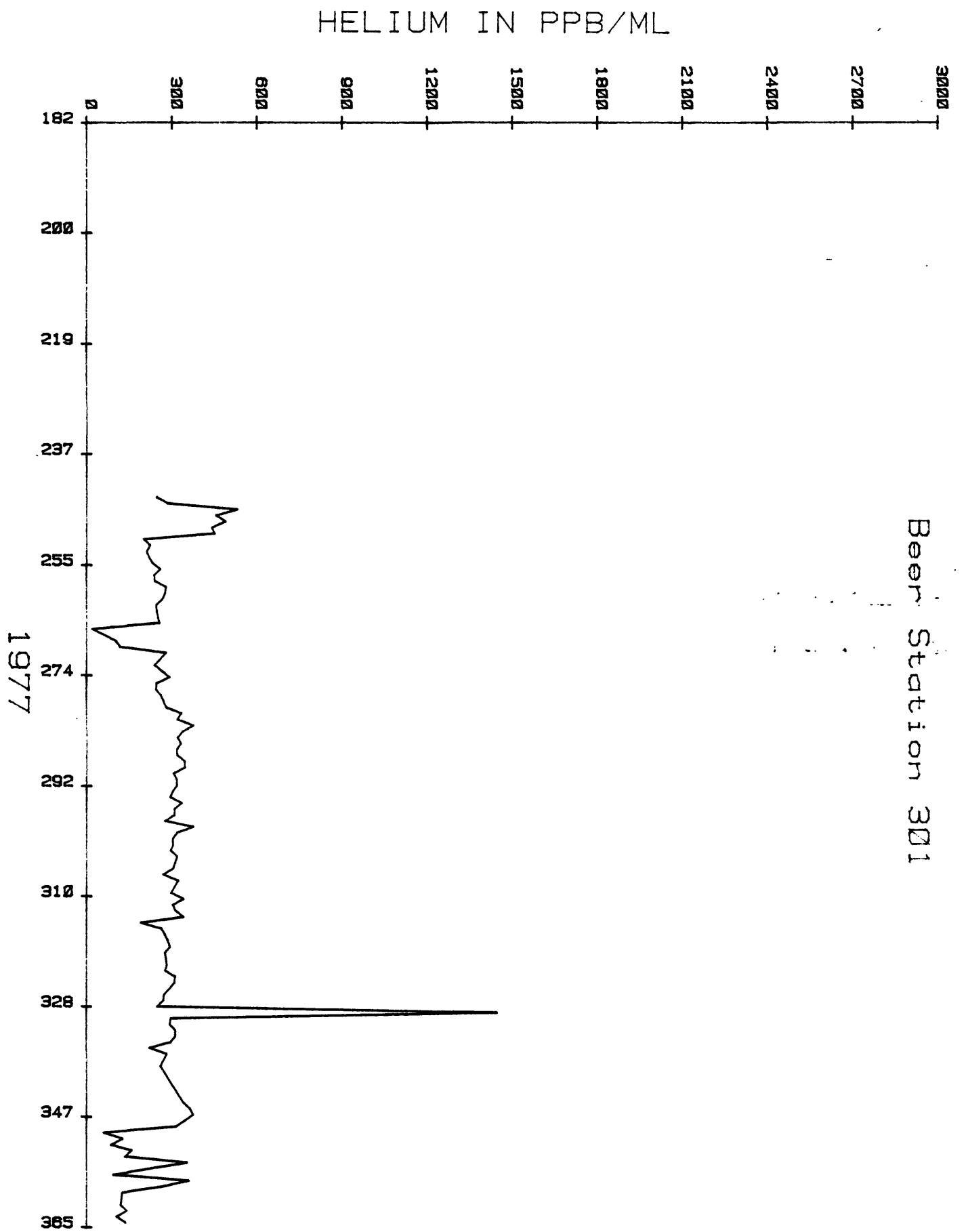


Figure 7.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1977.

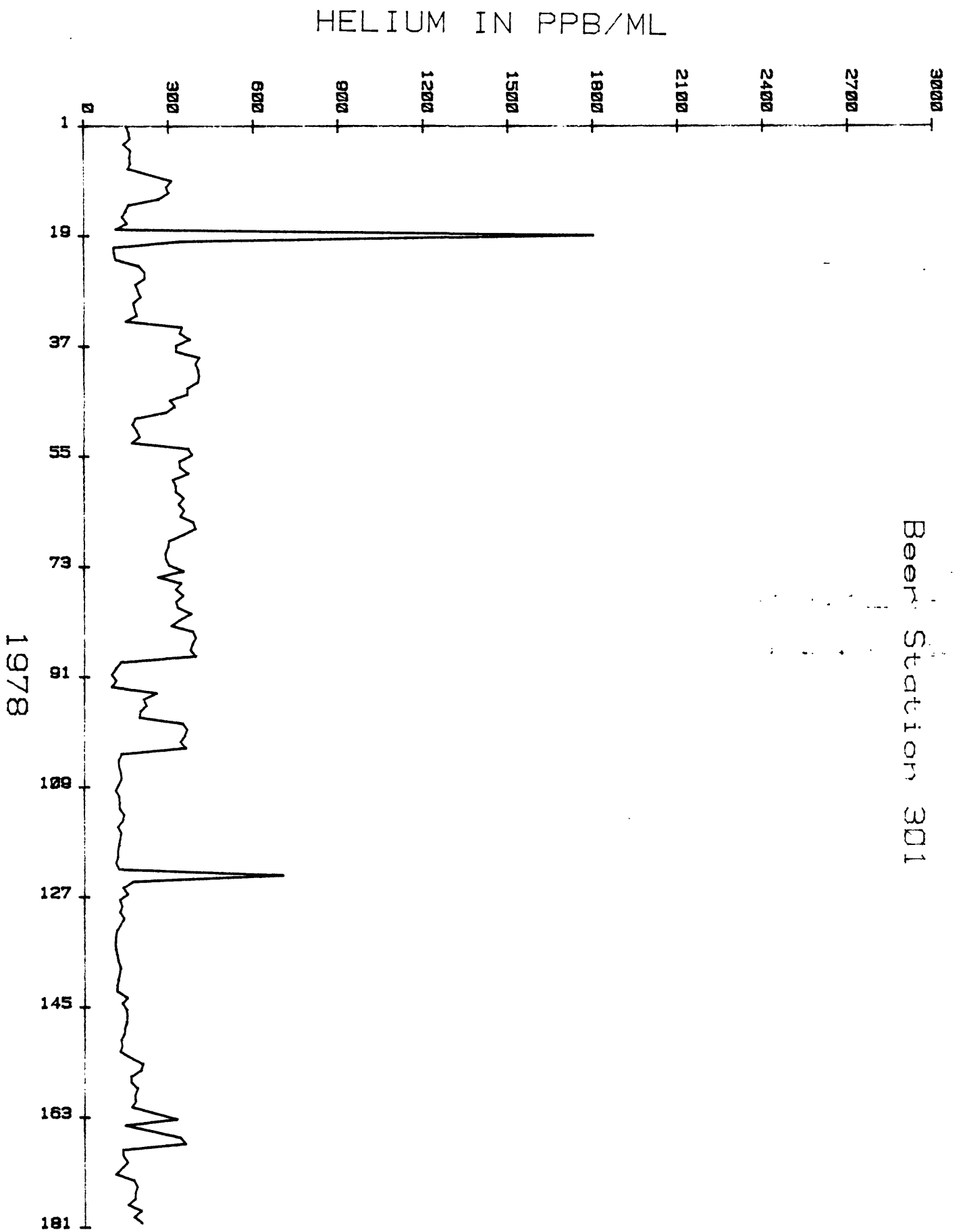


Figure 8.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1978.

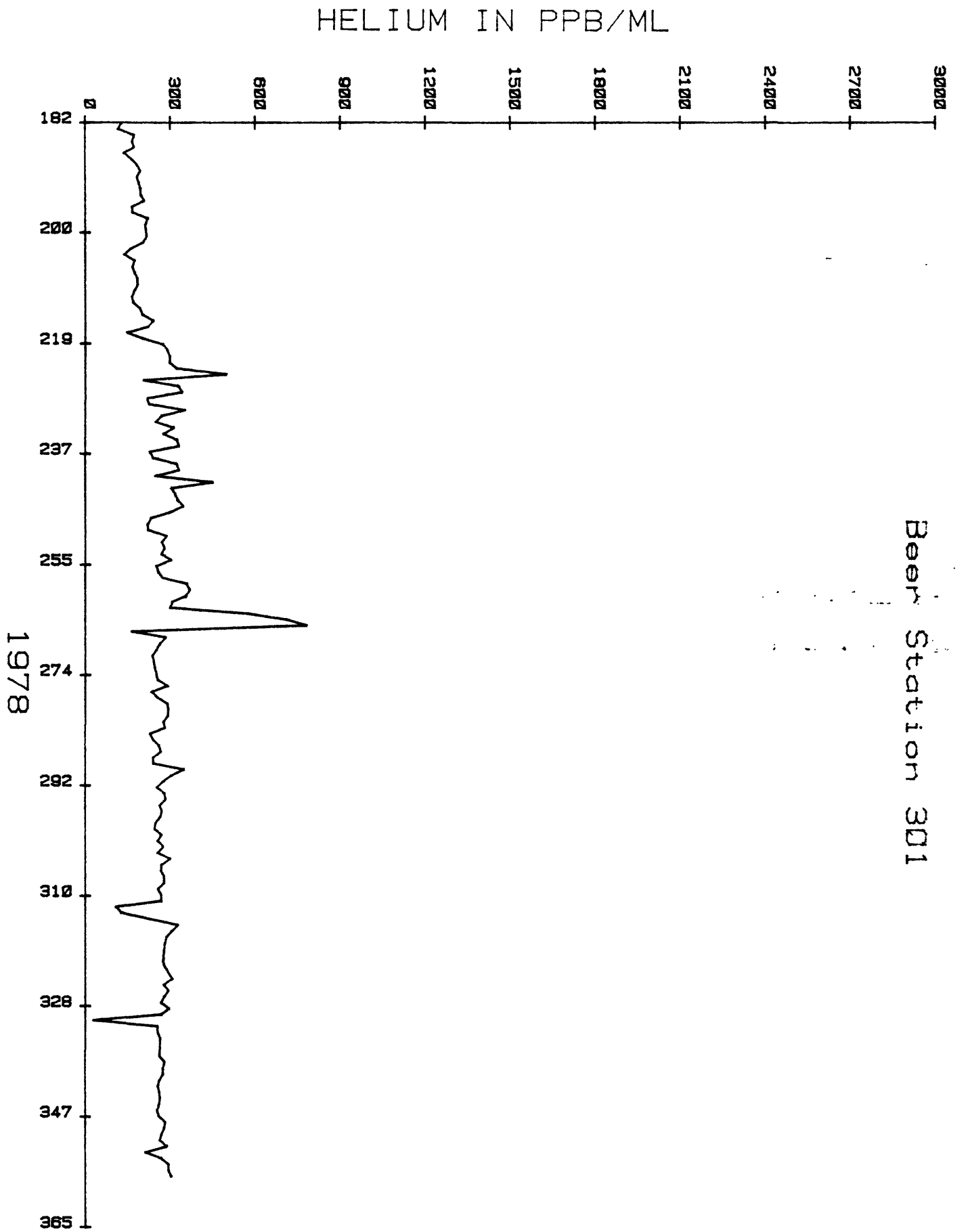


Figure 9.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1978.

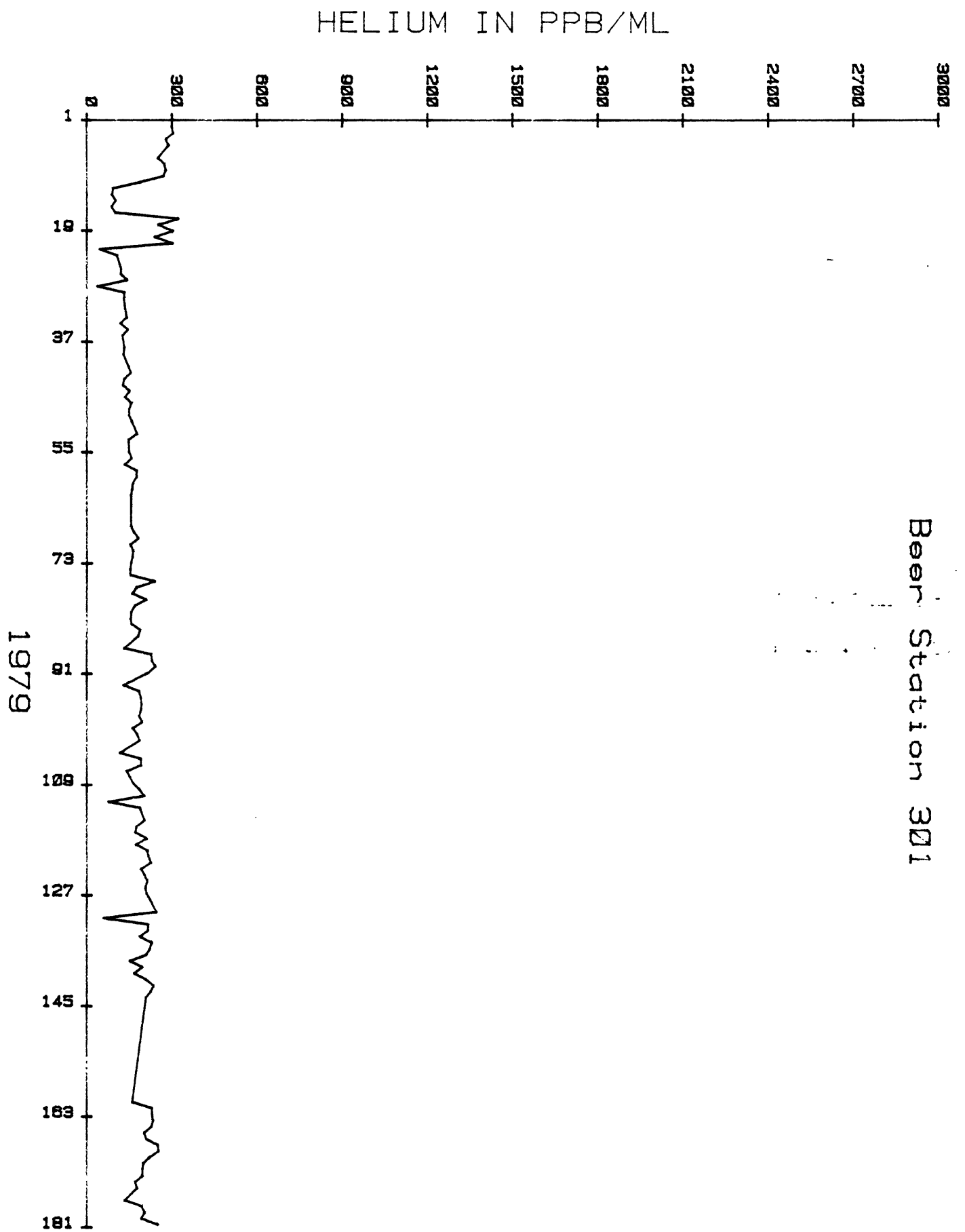


Figure 10.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1979.

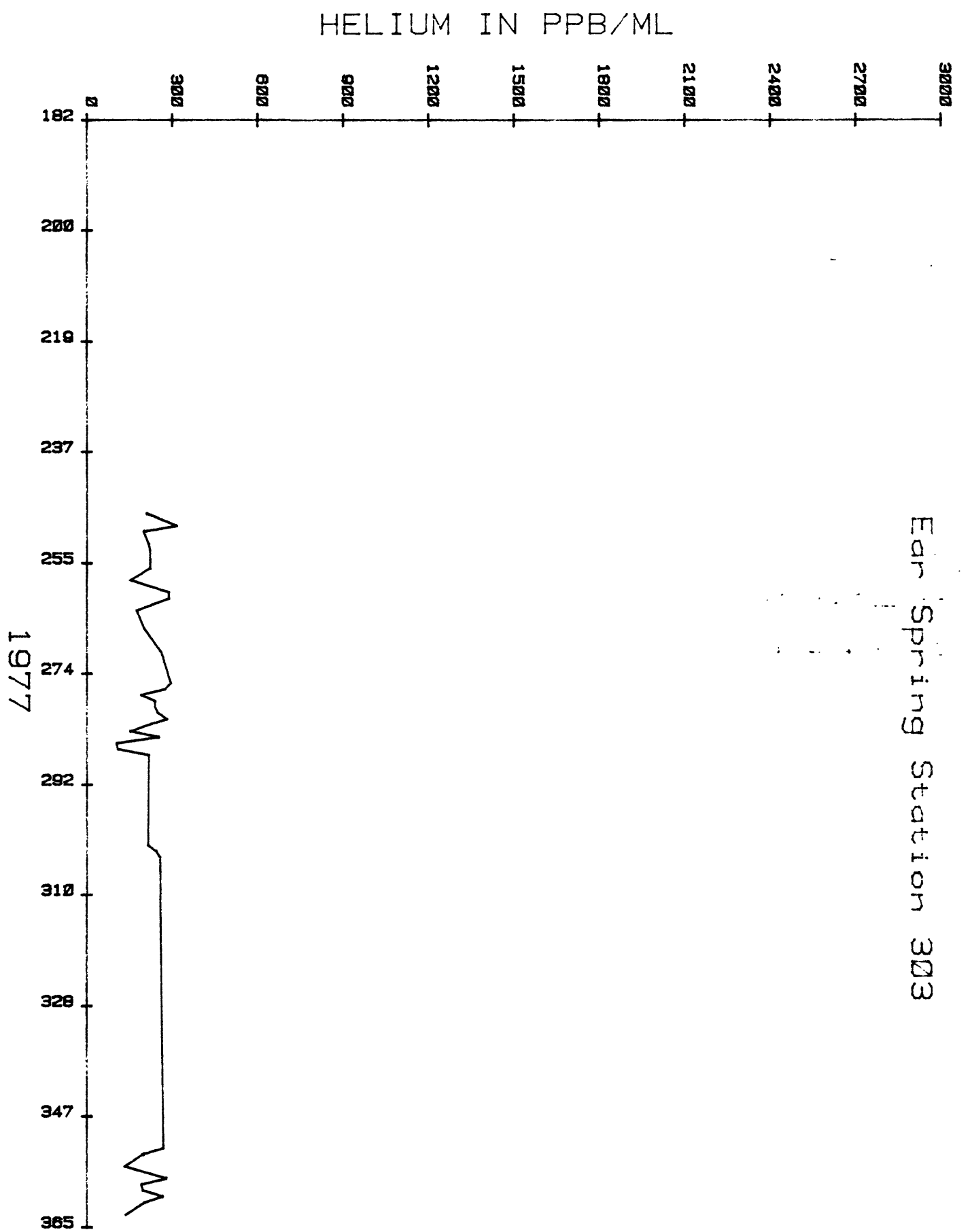


Figure 11.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, July through December, 1977.

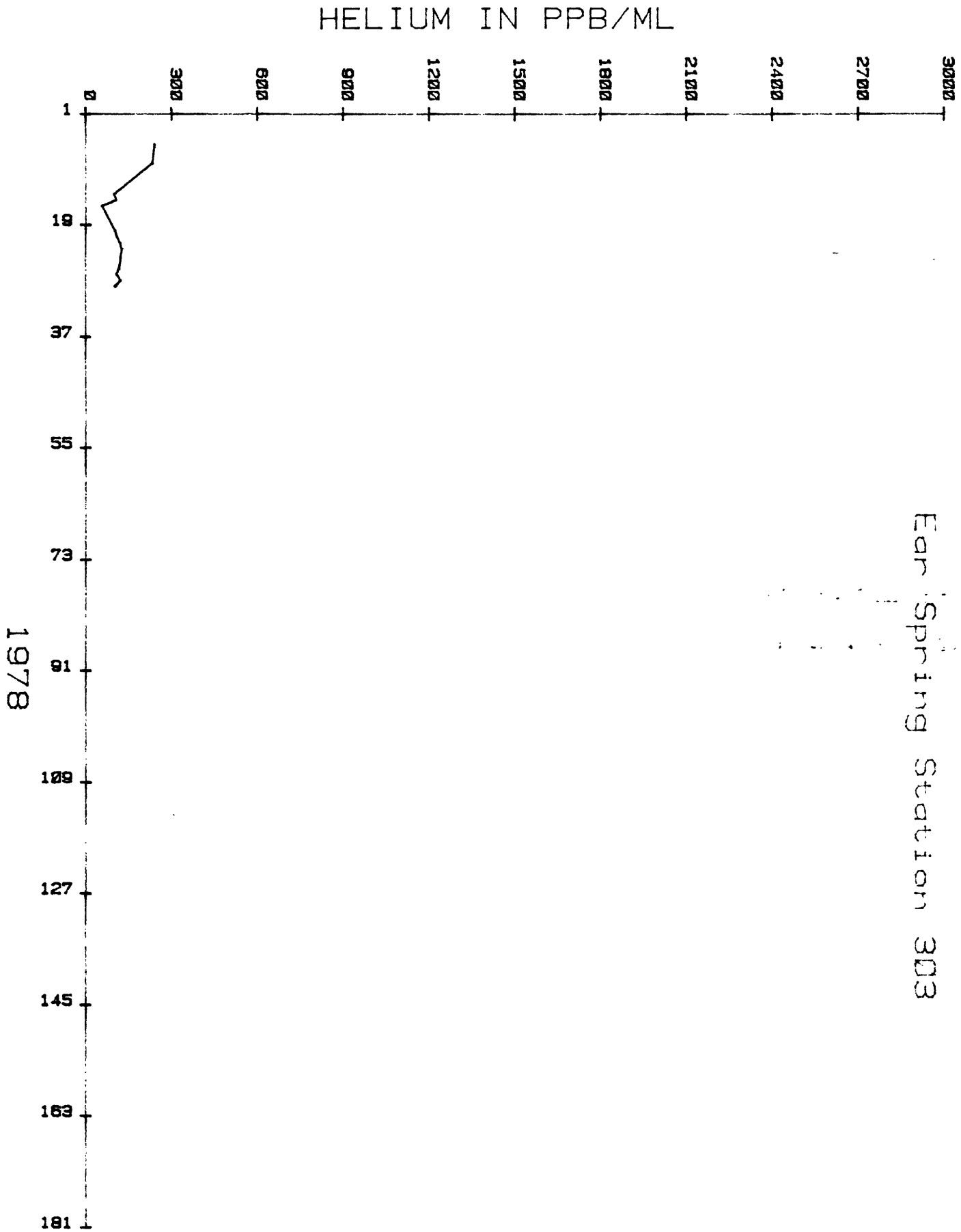


Figure 12.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, January through June, 1978.

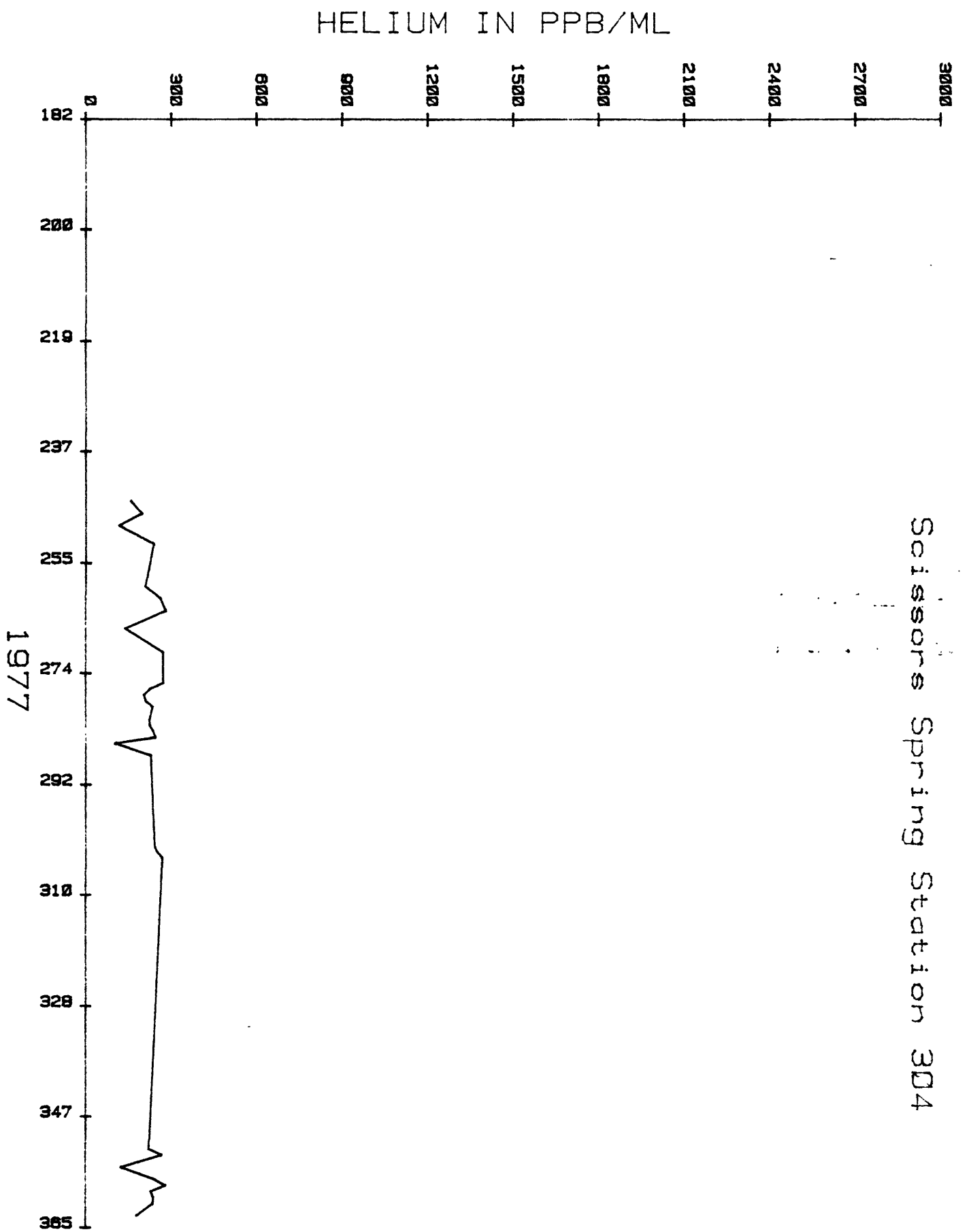


Figure 13.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, July through December, 1977.

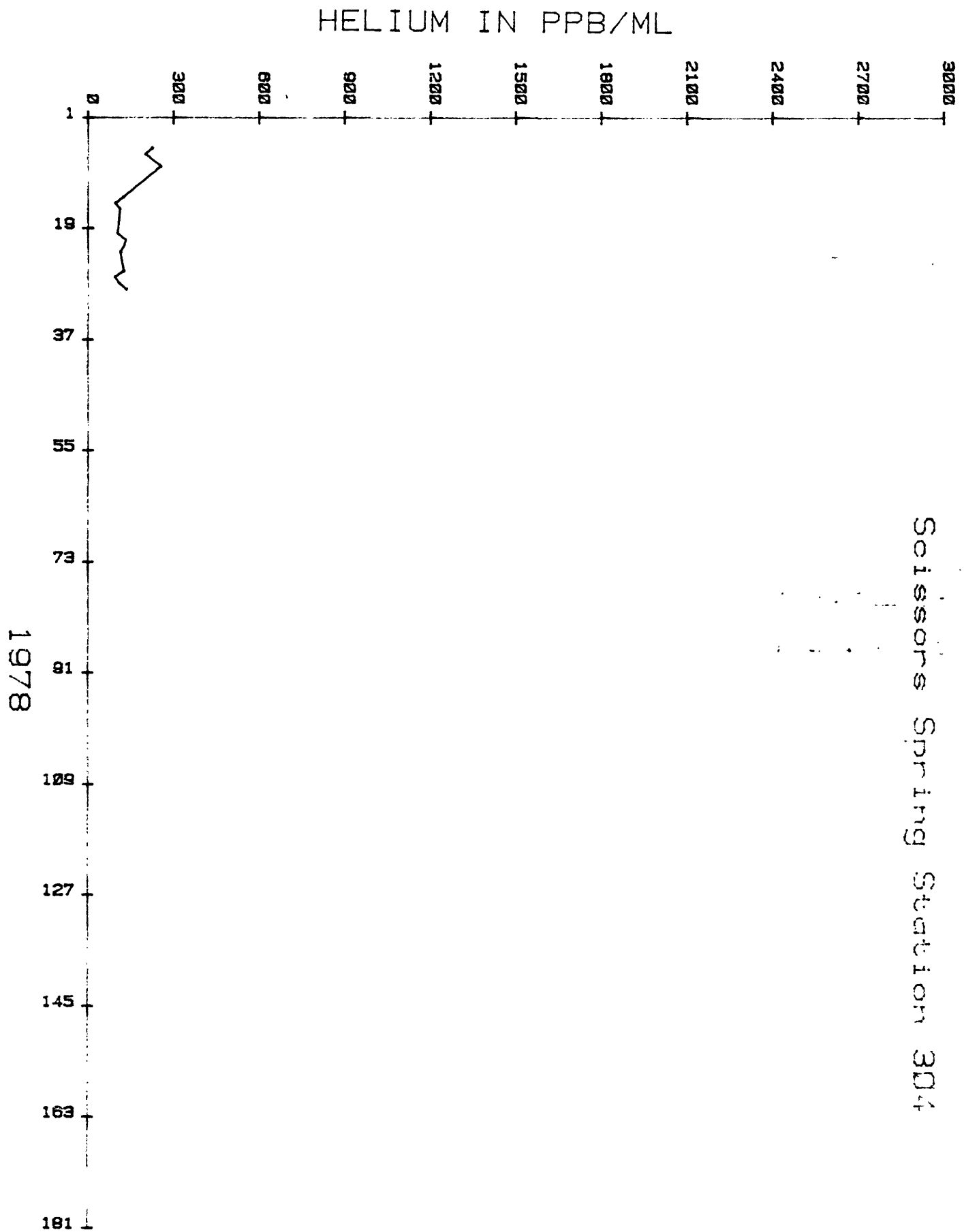


Figure 14.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, January through June, 1978.

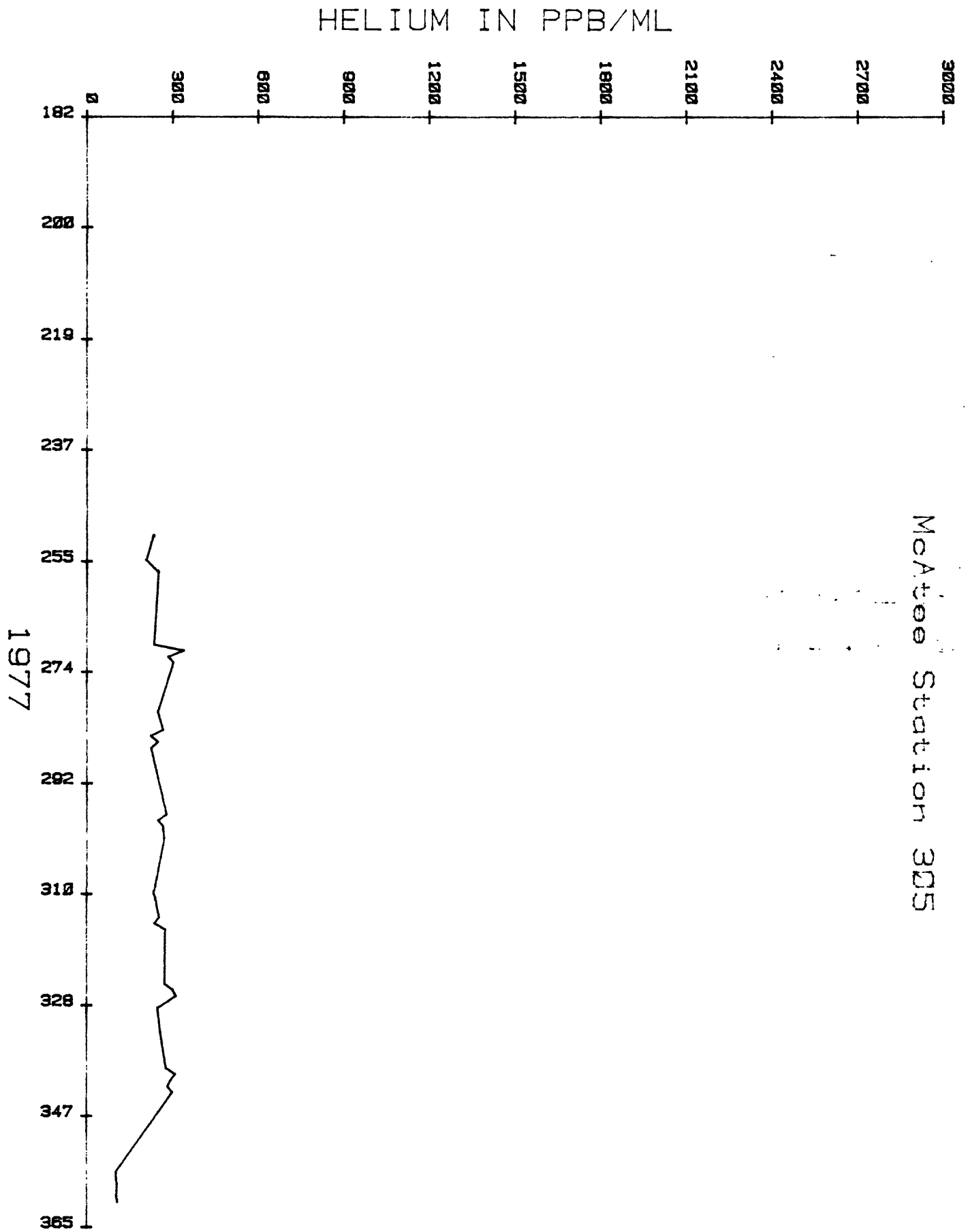


Figure 15.--Helium concentrations in water samples, Cameron, Montana, July through December, 1977.

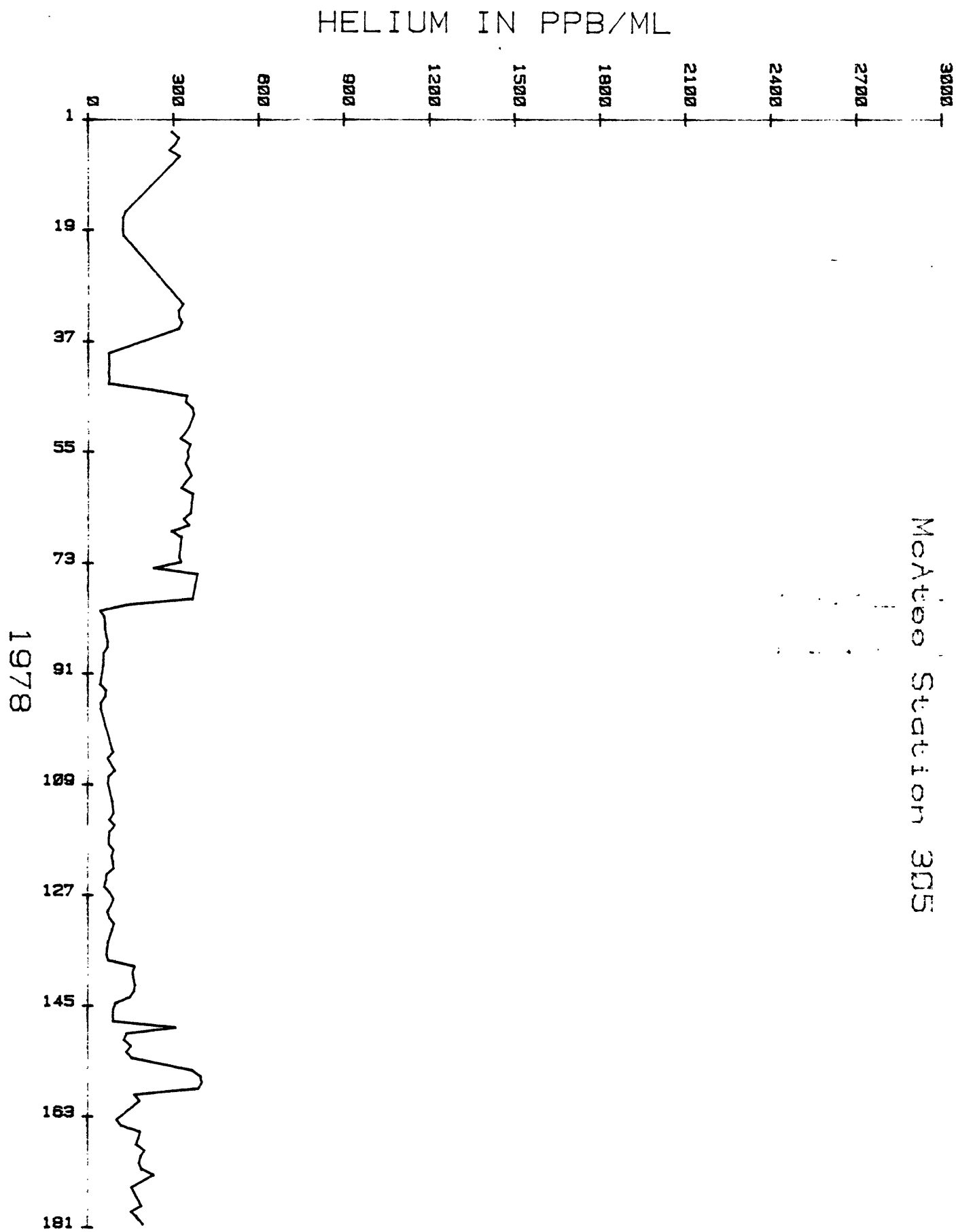


Figure 16.--Helium concentrations in water samples, Cameron, Montana, January through June, 1978.

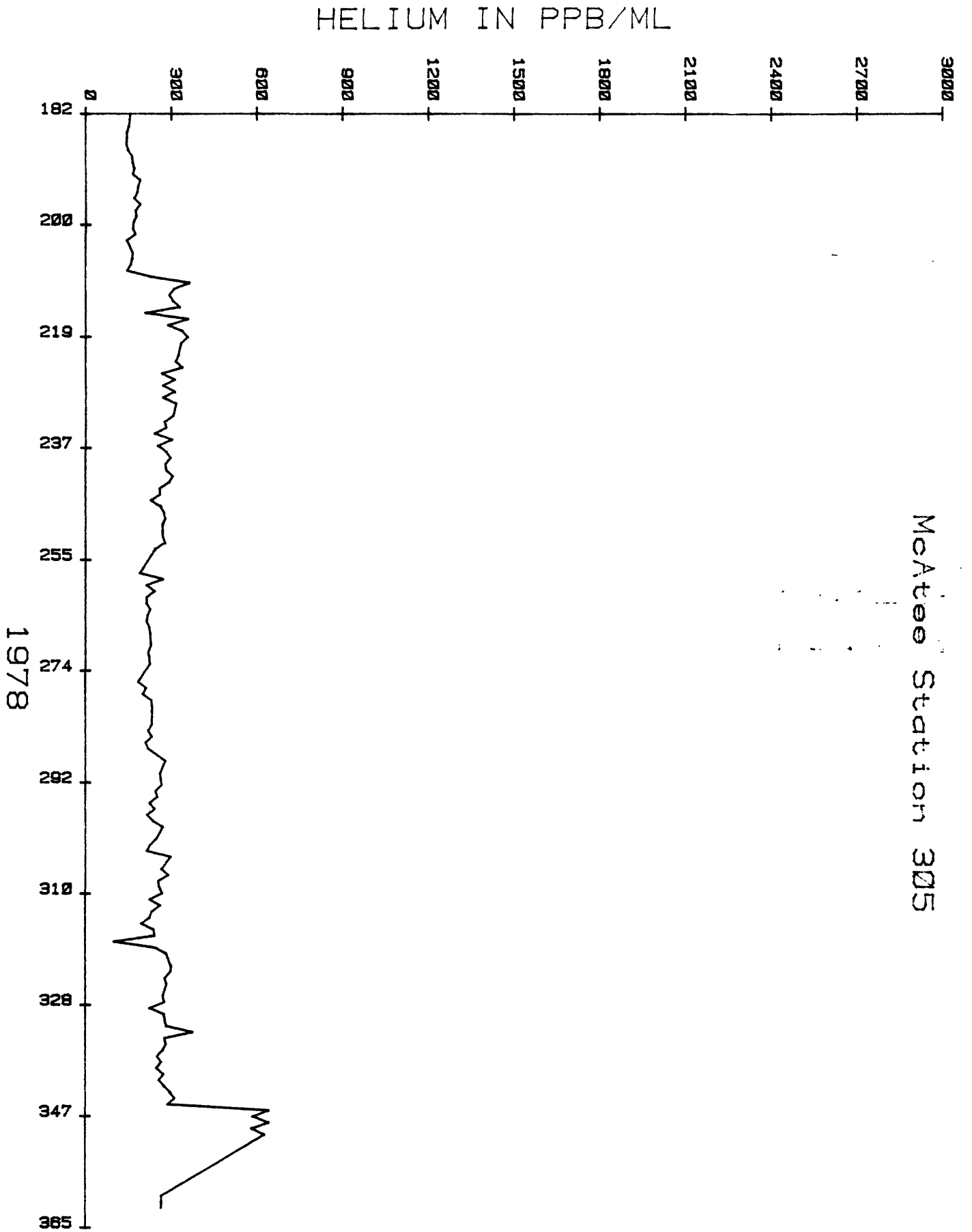


Figure 17.--Helium concentrations in water samples, Cameron, Montana, July through December, 1978.

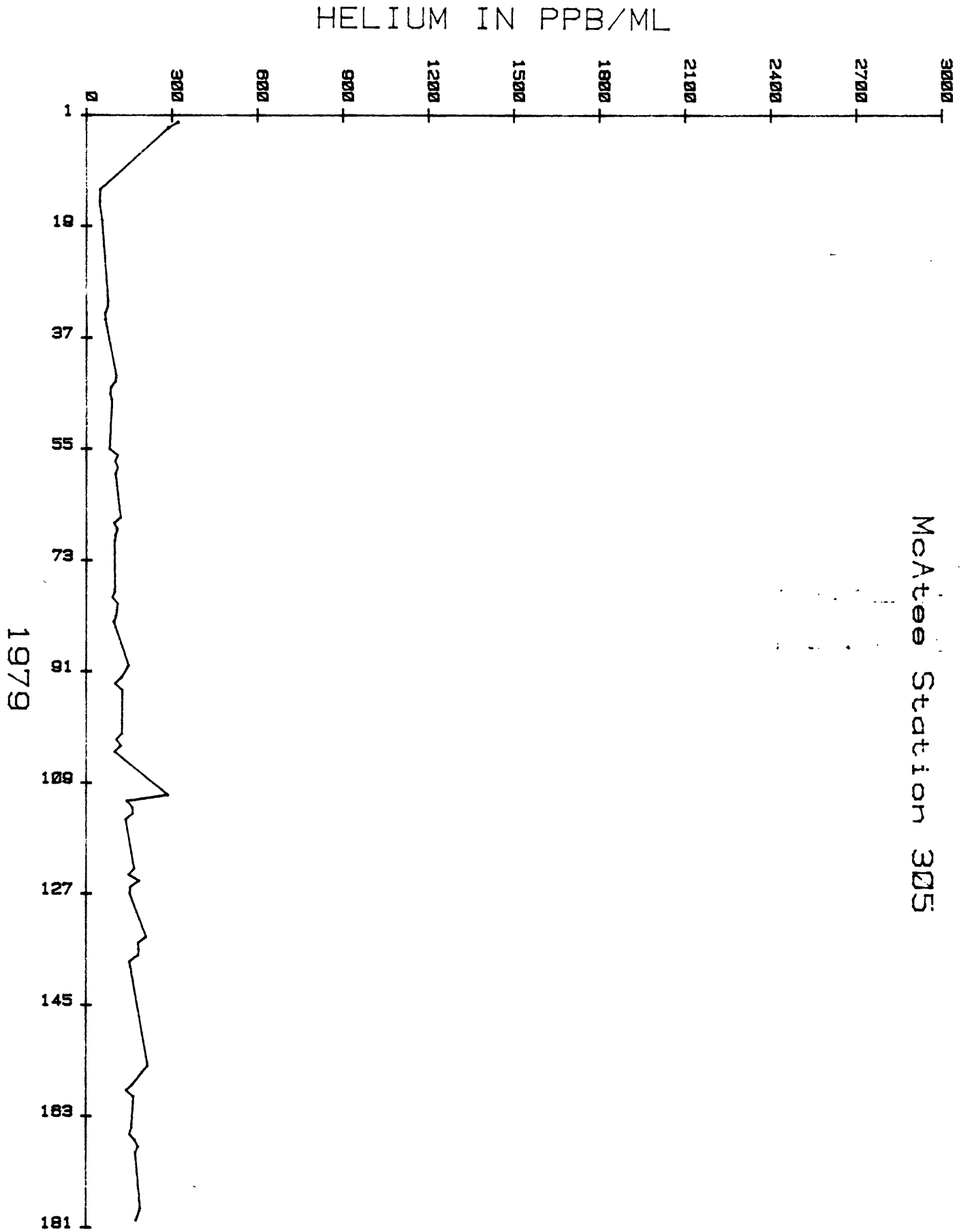


Figure 18.--Helium concentrations in water samples, Cameron, Montana, January through June, 1979.

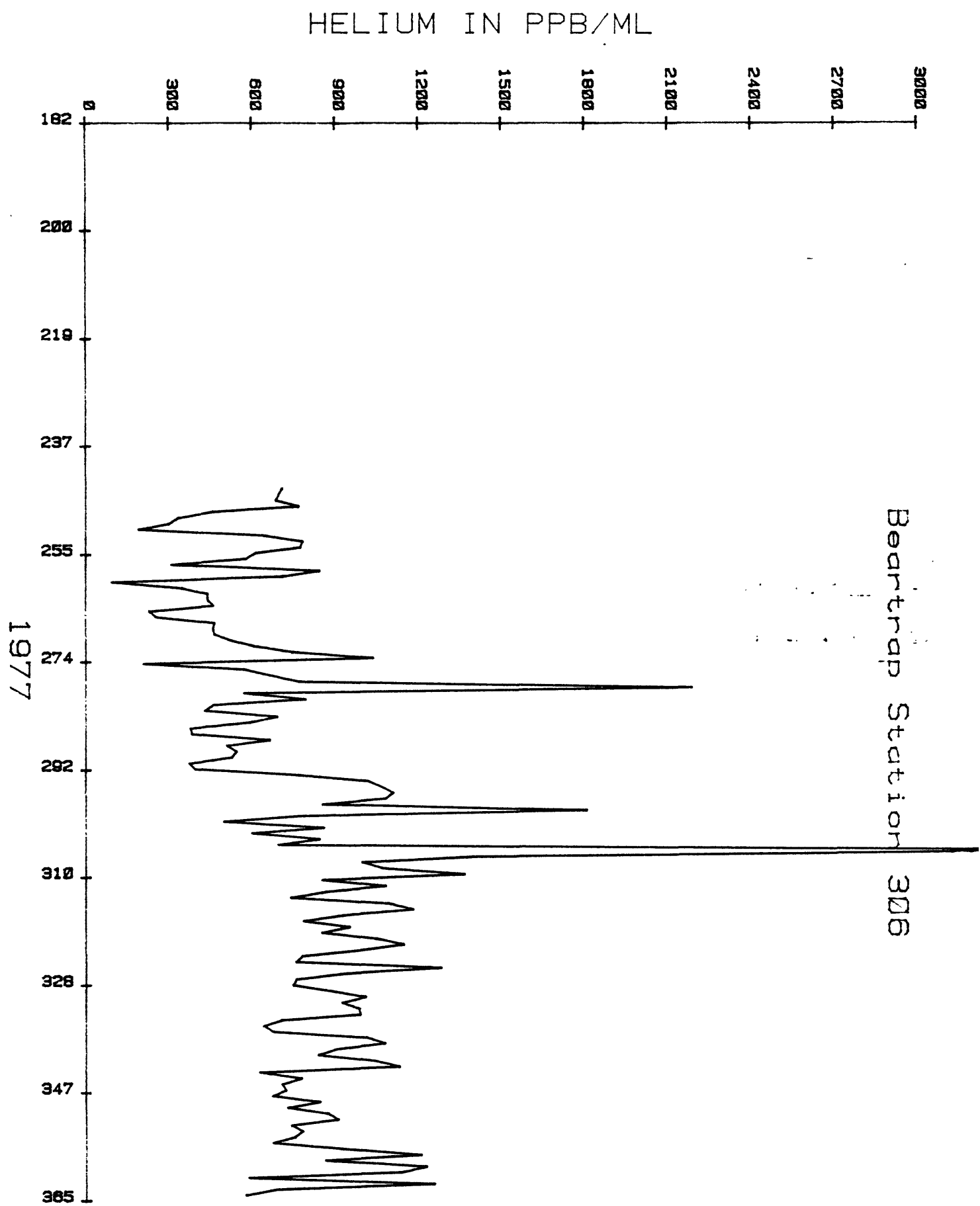


Figure 19.--Helium concentrations in water samples, Norris, Montana, July through December, 1977.

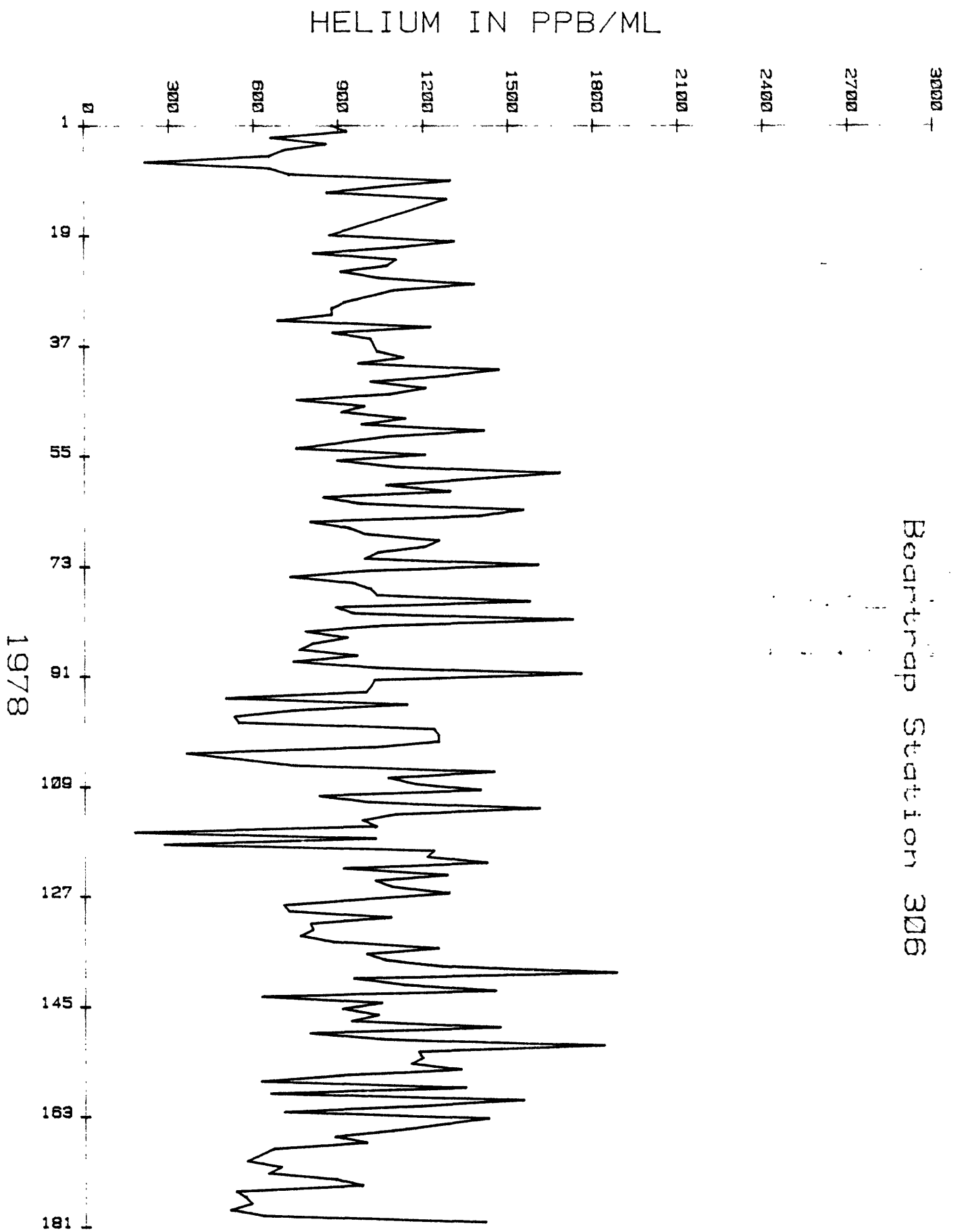


Figure 20.--Helium concentrations in water samples, Norris, Montana, January through June, 1978.

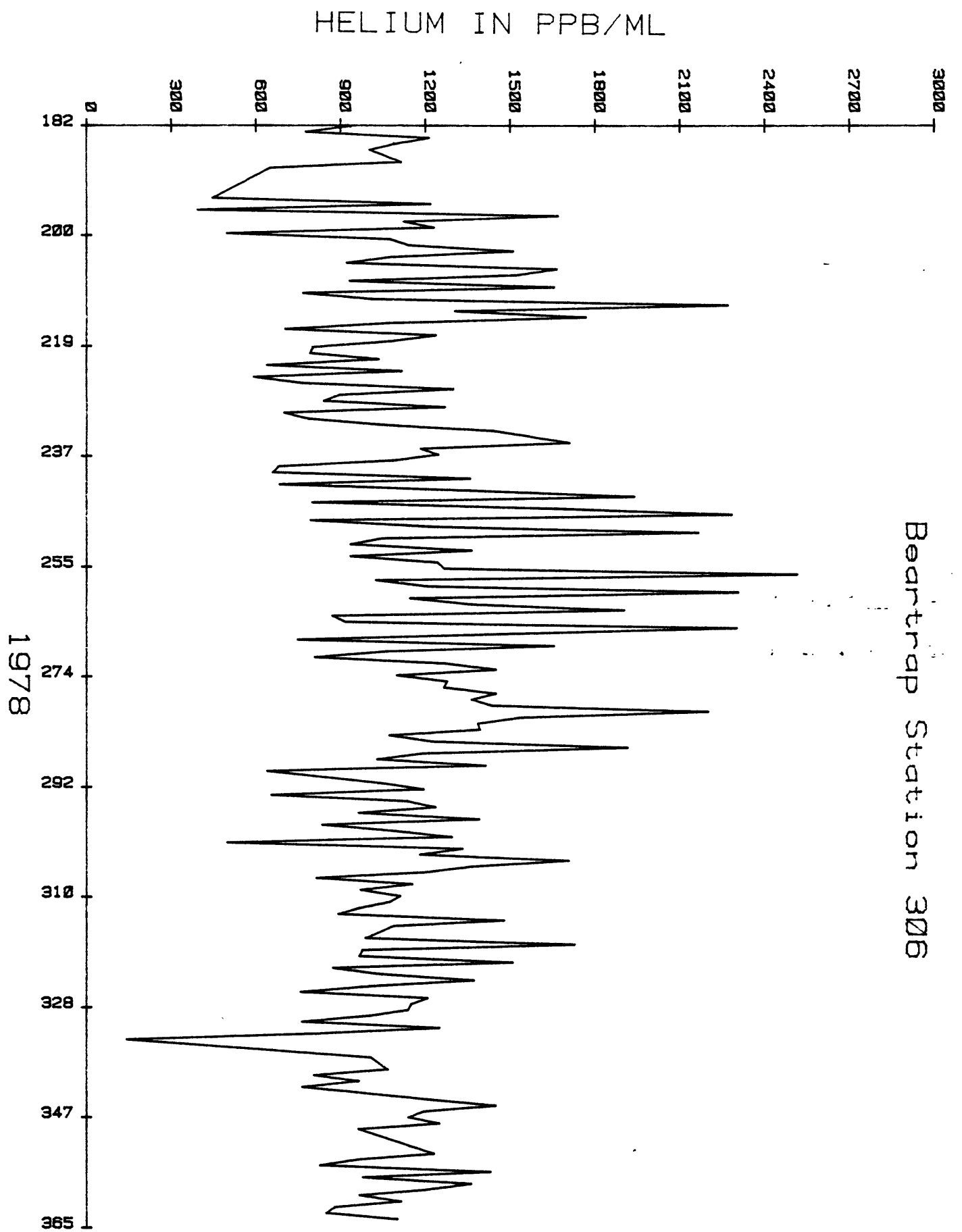


Figure 21.--Helium concentrations in water samples, Norris, Montana, July through December, 1978.

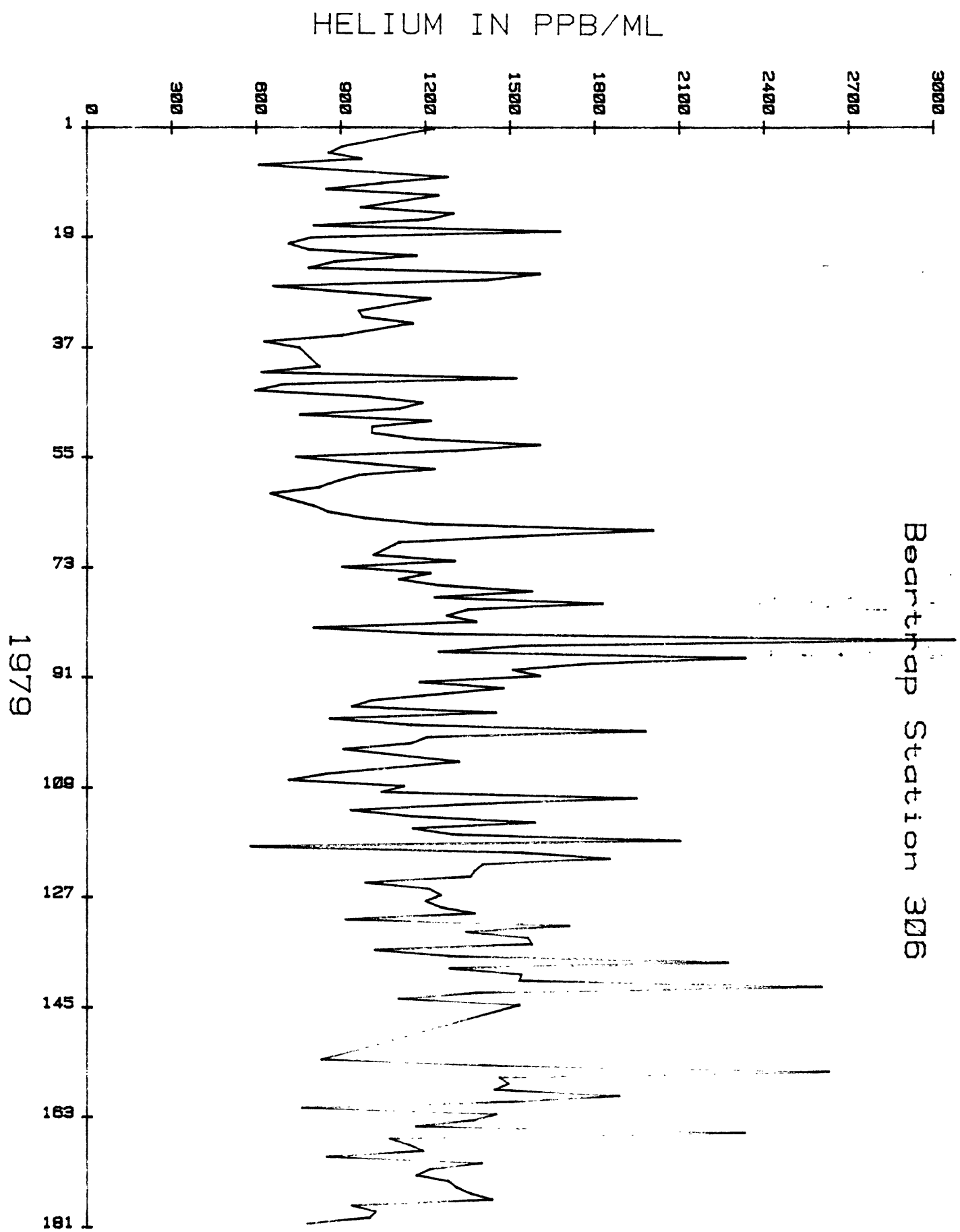


Figure 22.--Helium concentrations in water samples, Norris, Montana, January through June, 1979.

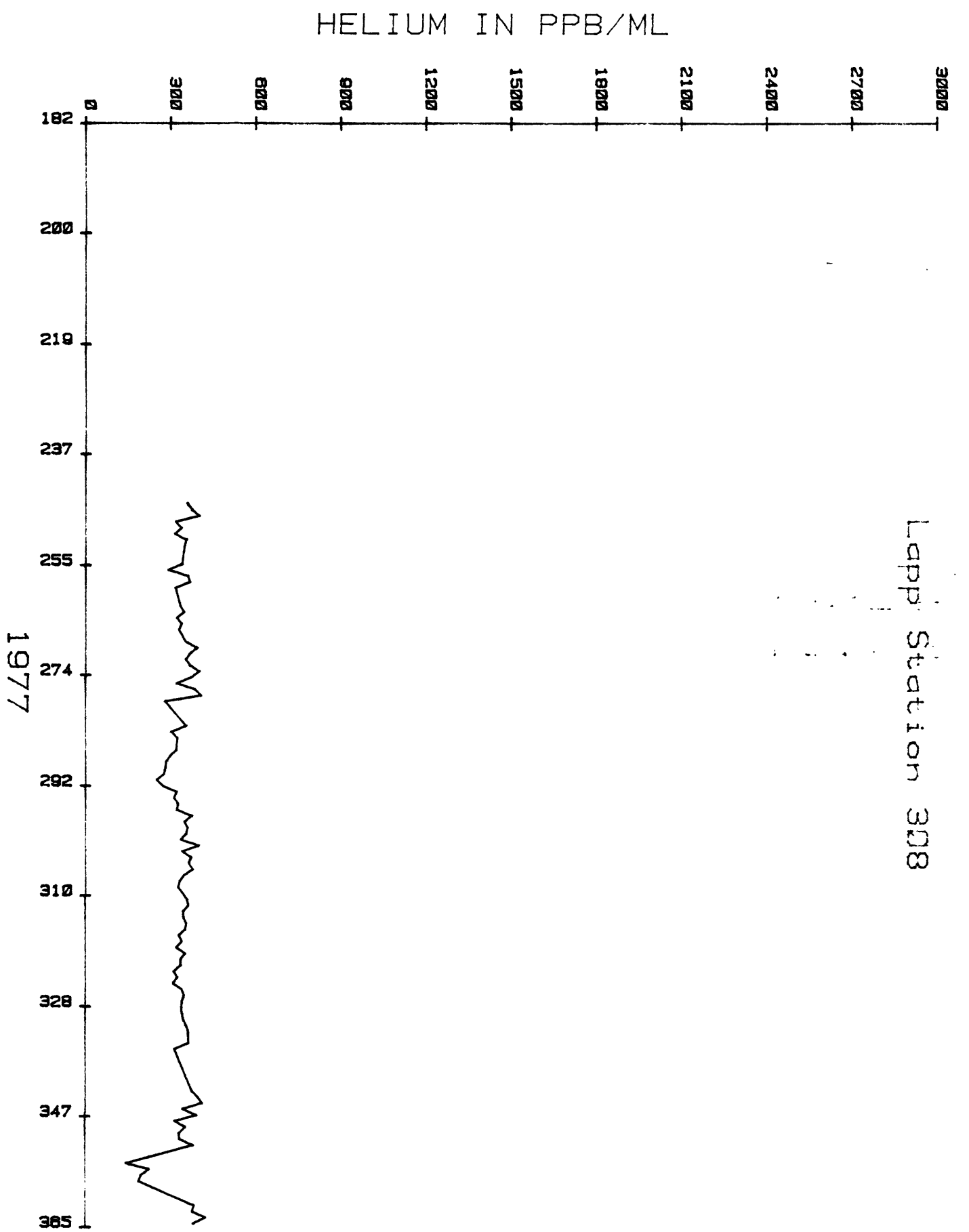


Figure 23.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1977.

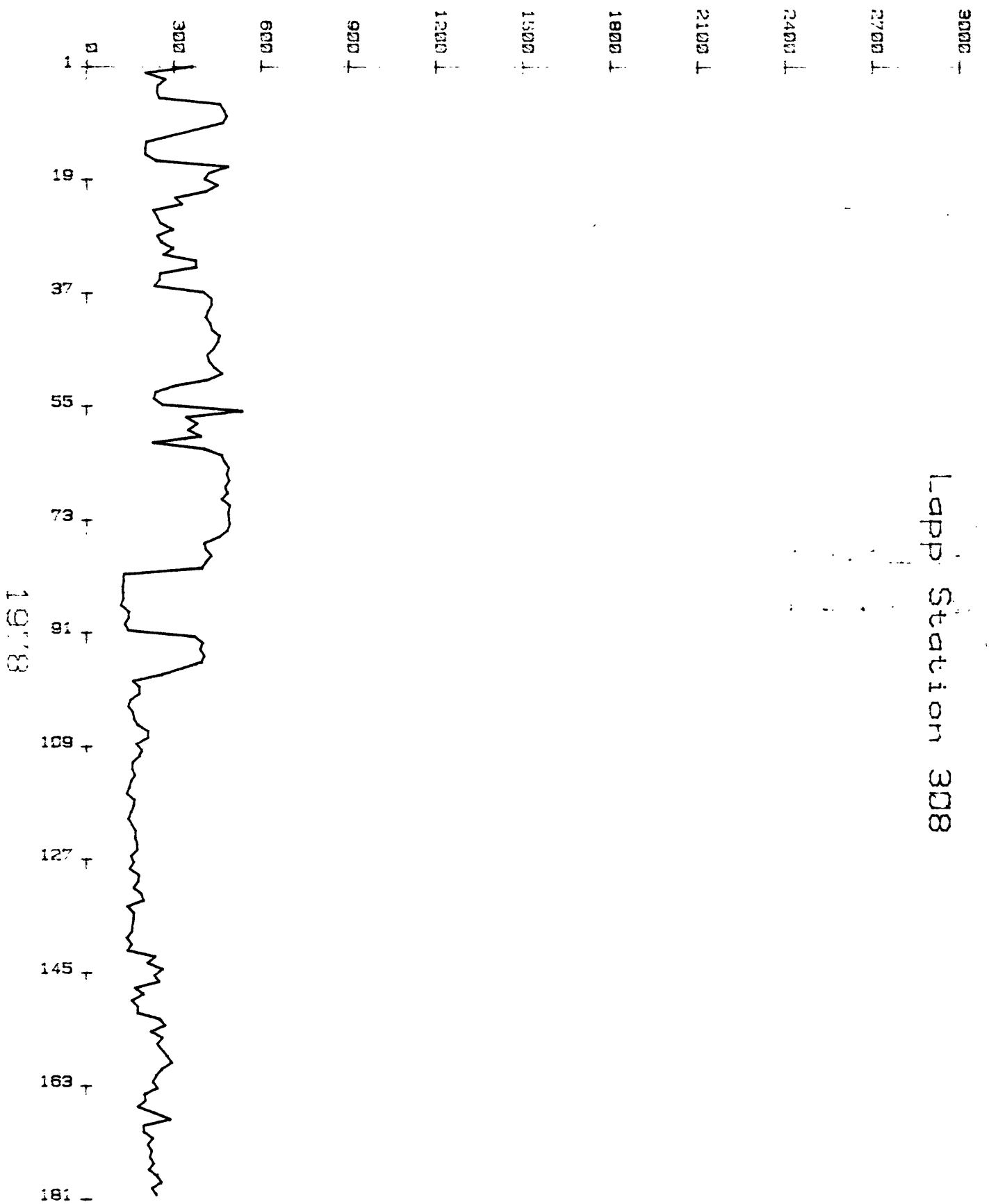


Figure 24.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1978.

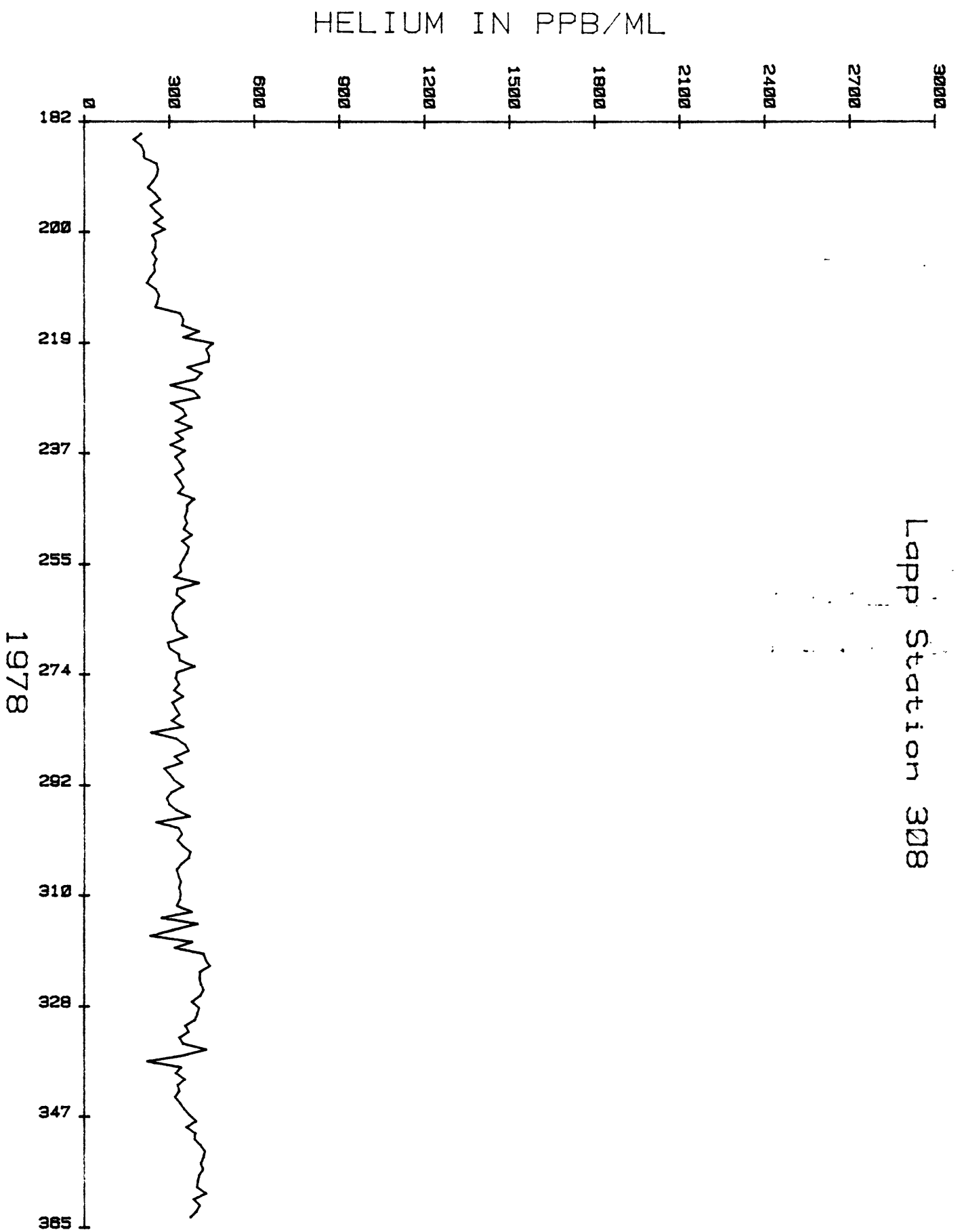


Figure 25.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1978.

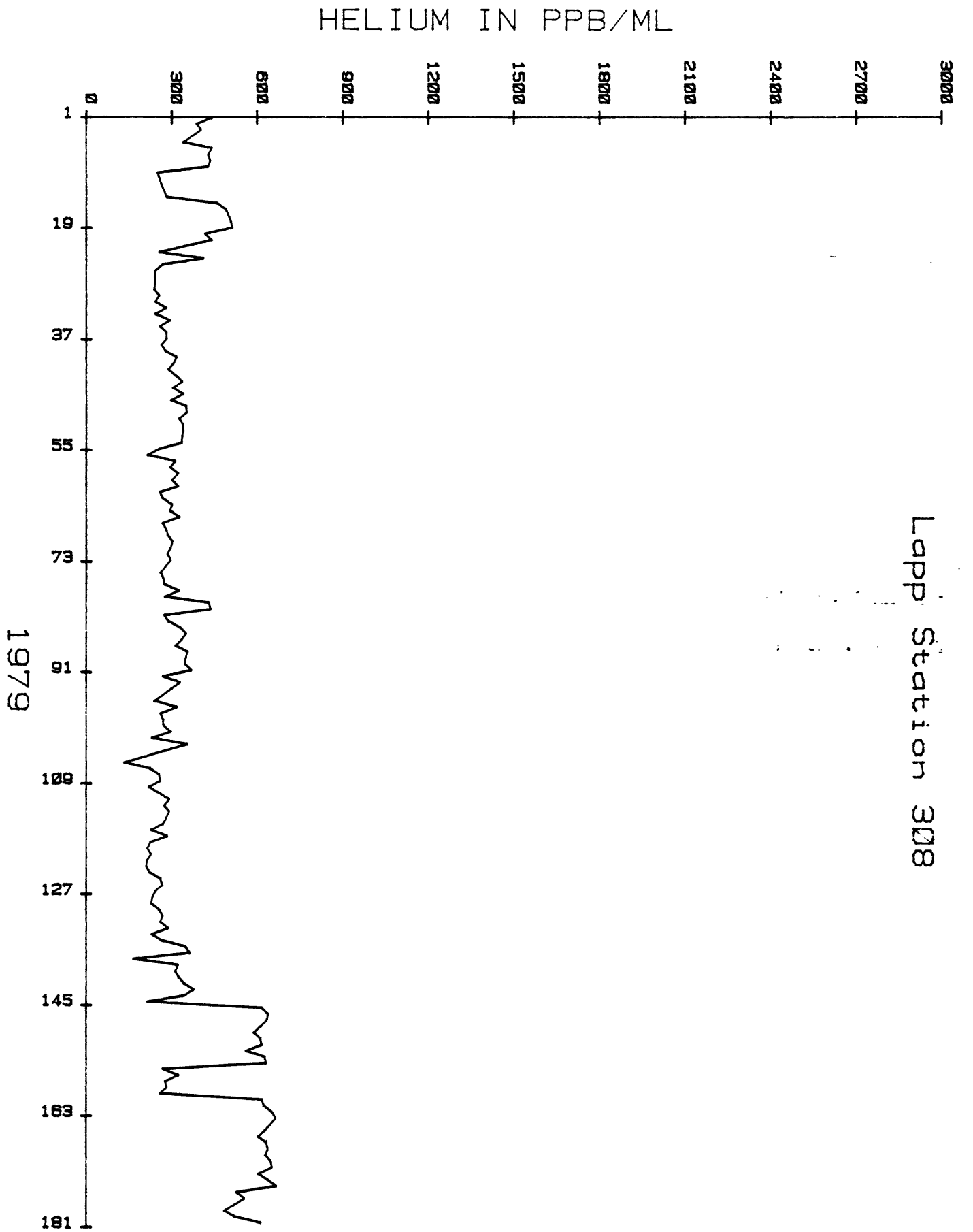
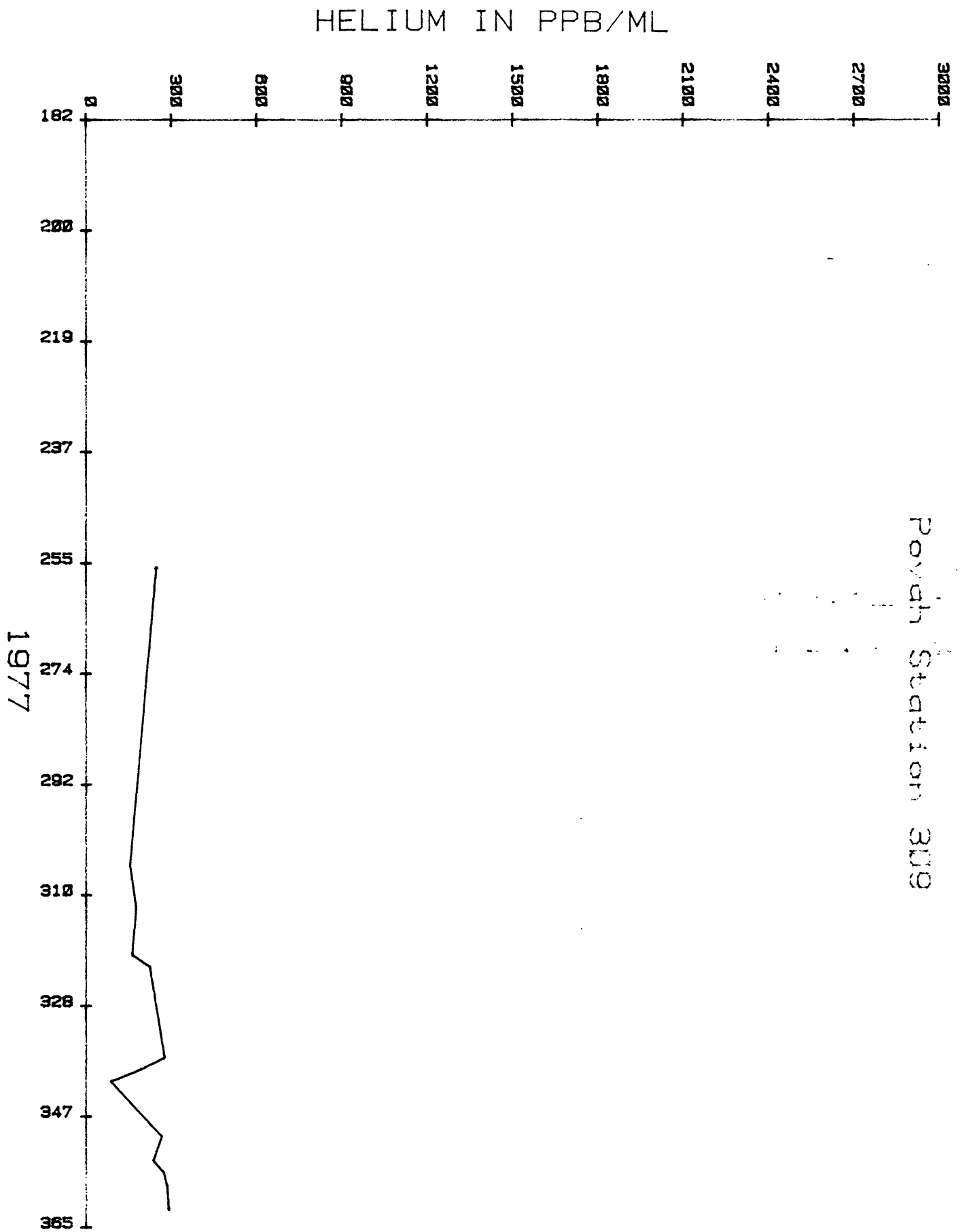


Figure 26.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1979.



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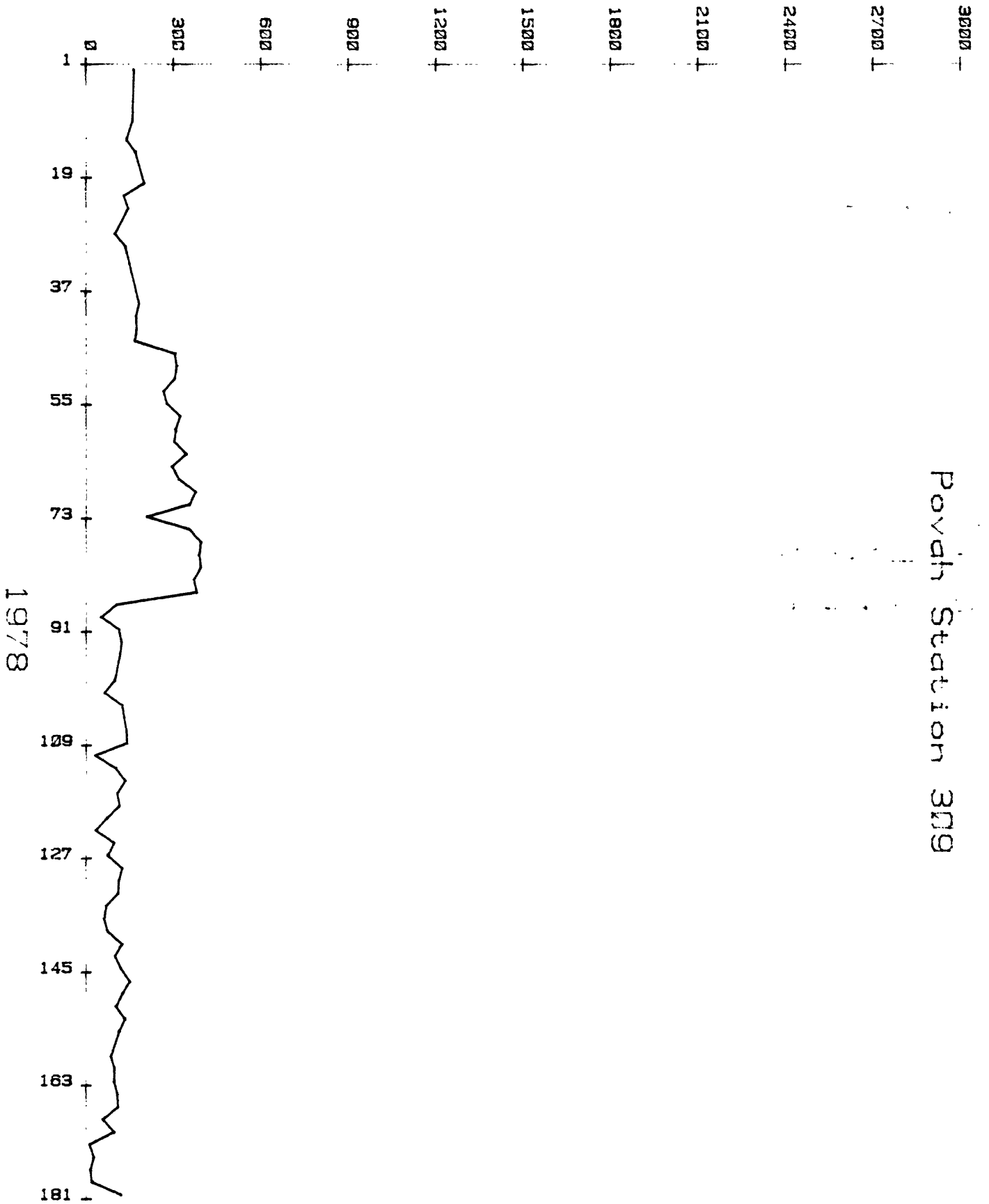

Figure 28.--Helium concentrations in water samples, West Yellowstone, Montana, January through June, 1978.

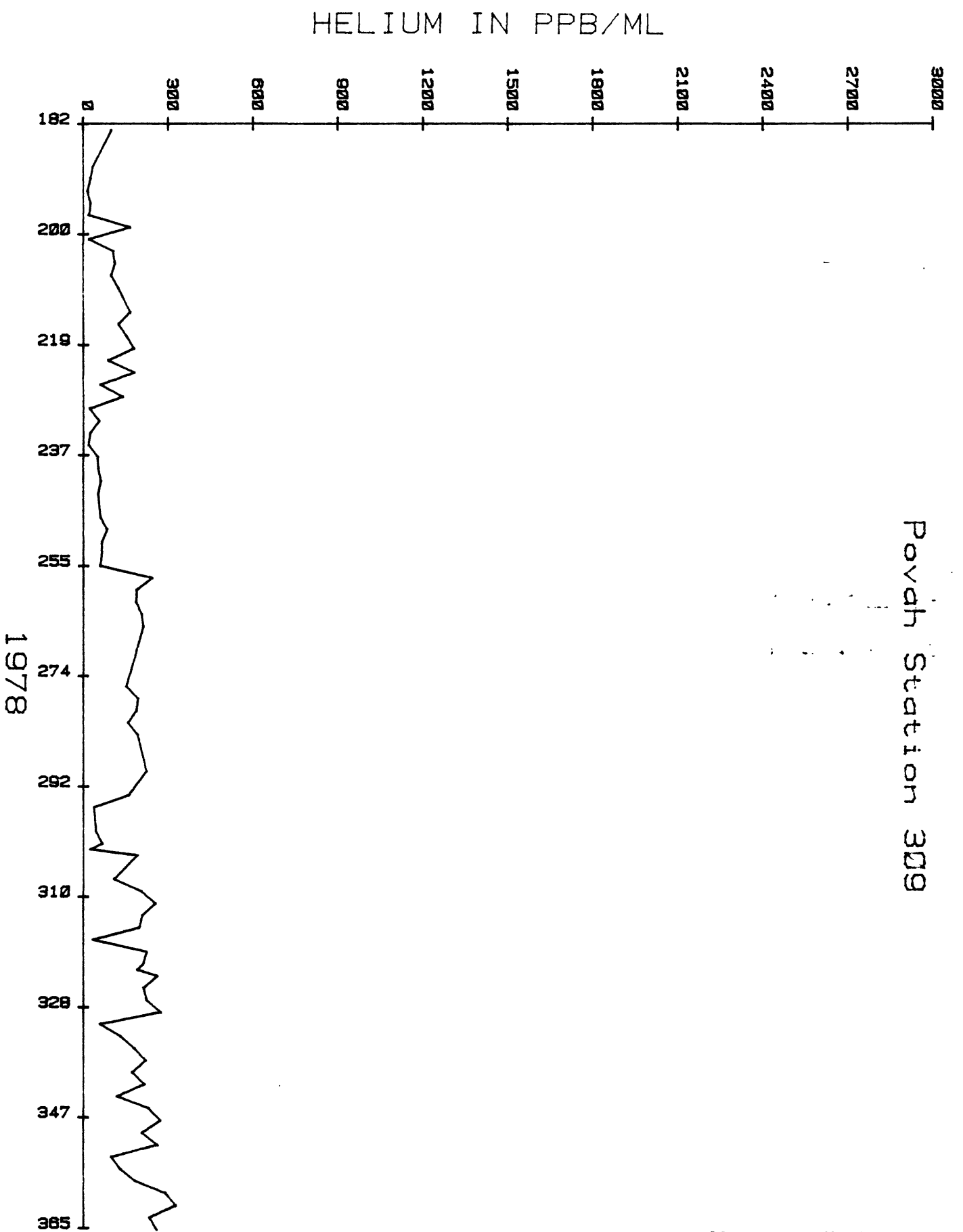

Figure 29.--Helium concentrations in water samples, West Yellowstone, Montana, July through December, 1978.

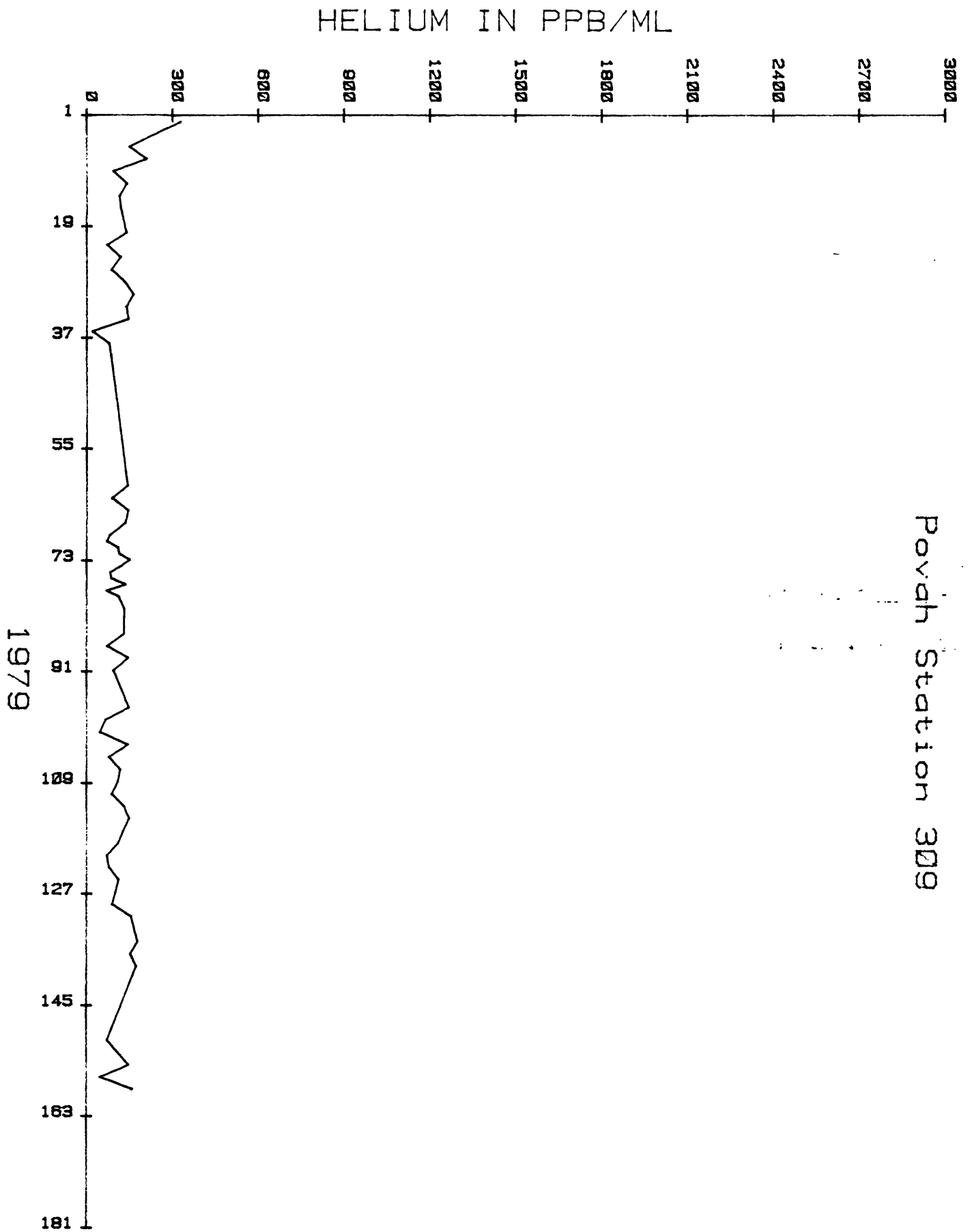

Figure 30.--Helium concentrations in water samples, West Yellowstone, Montana, January through July, 1979.

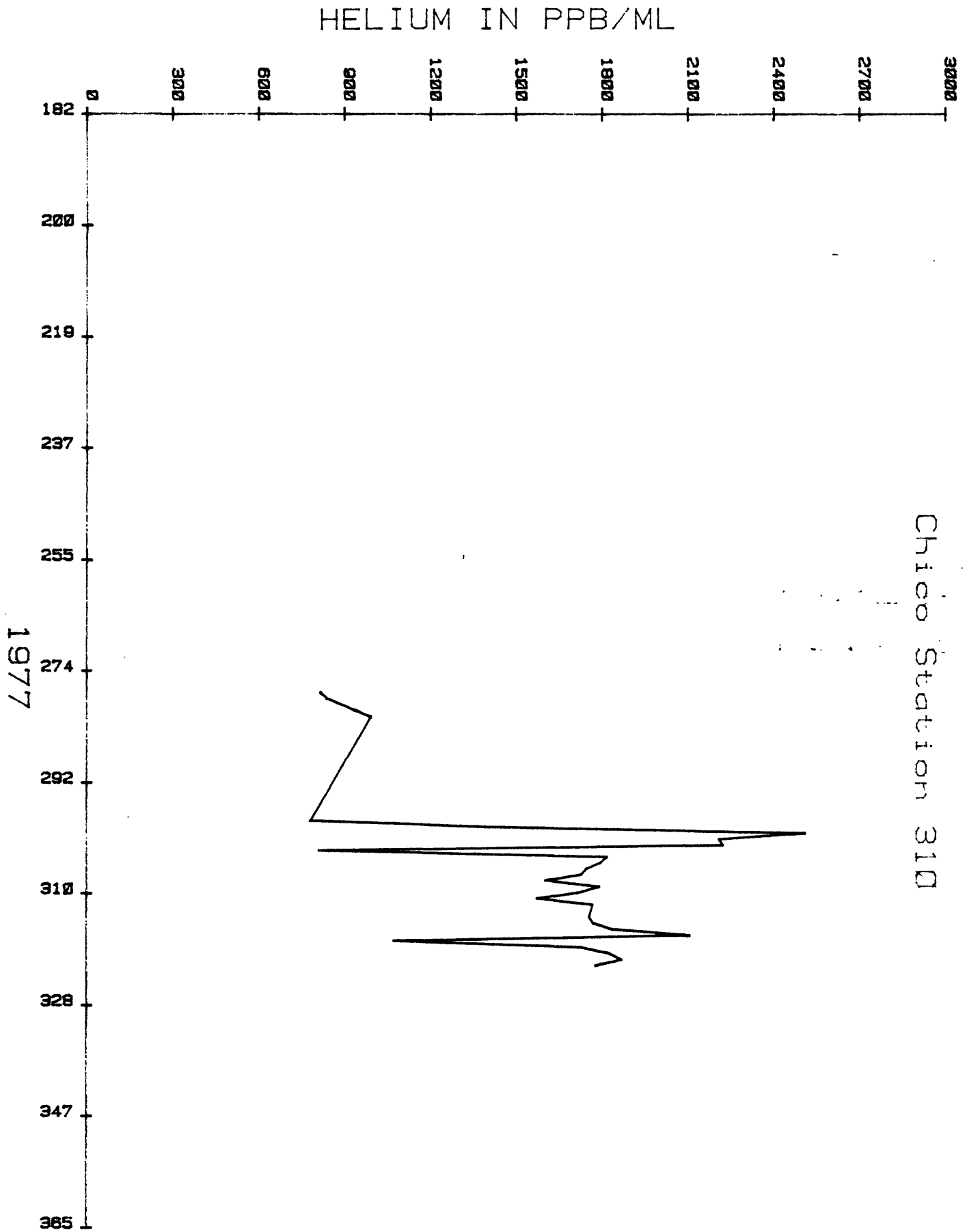

Figure 31.--Helium concentrations in water samples, Pray, Montana, July through December, 1977.

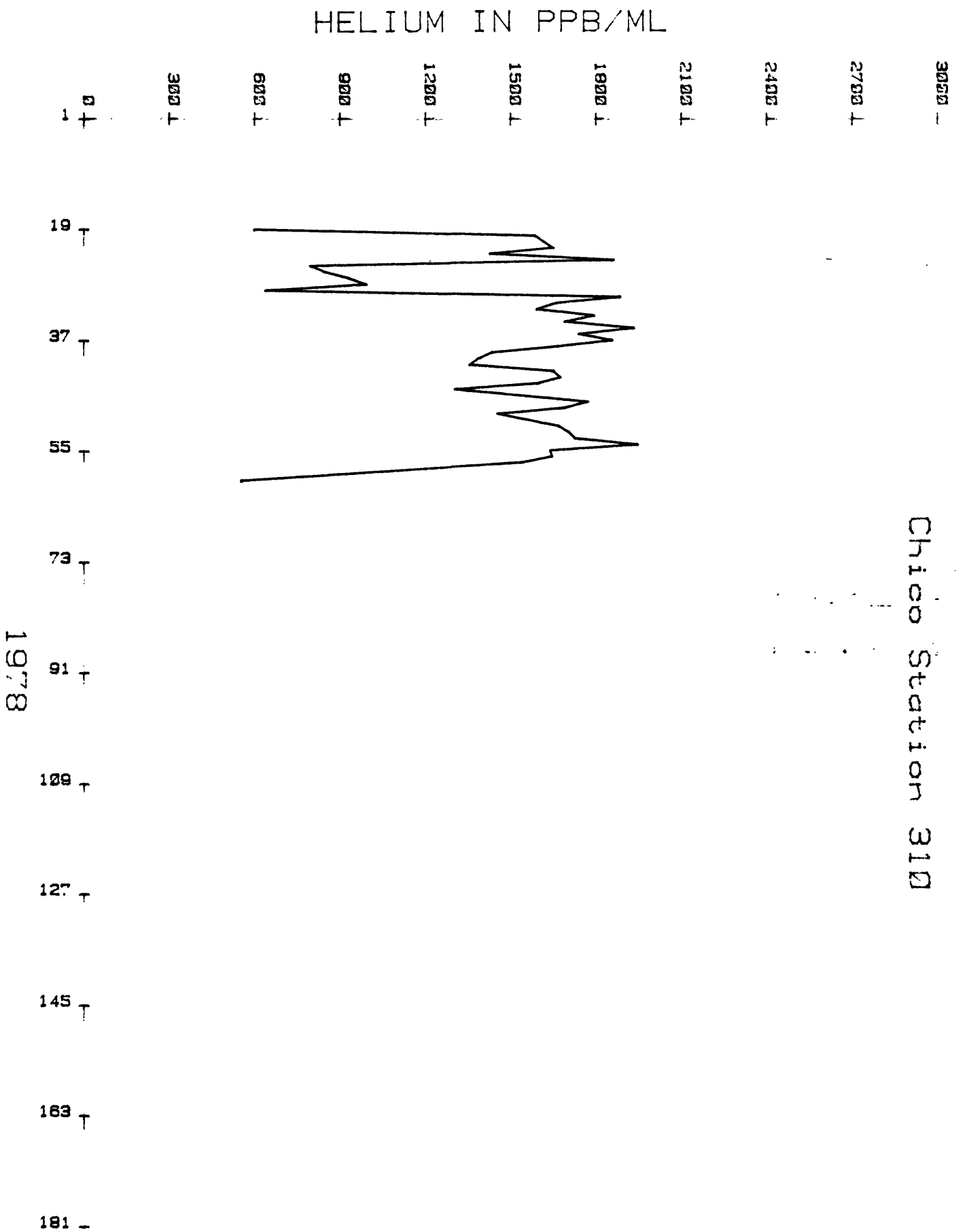

Figure 32.--Helium concentrations in water samples, Pray, Montana, January through June, 1978.

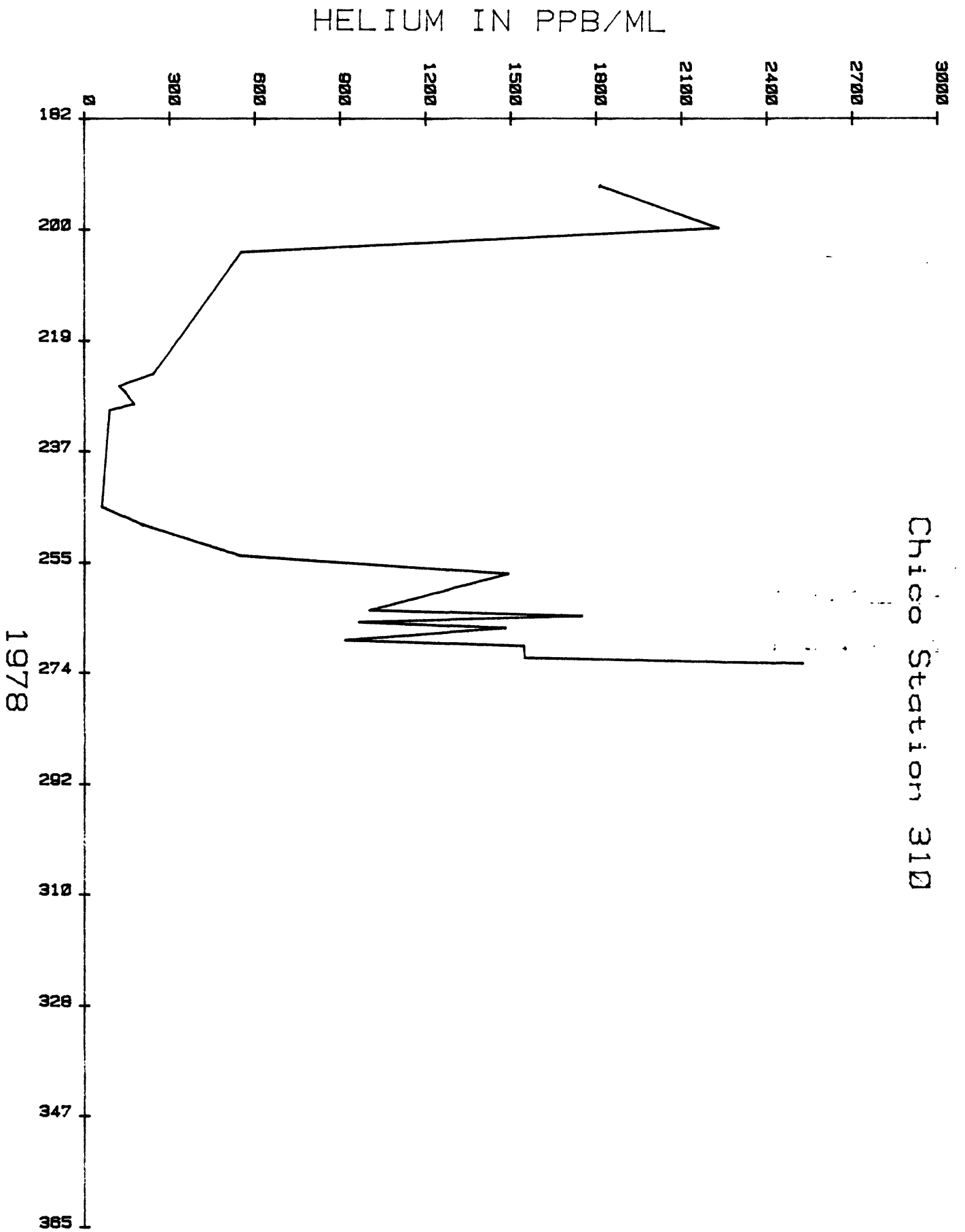

Figure 33.--Helium concentrations in water samples, Pray, Montana, July through December, 1978.

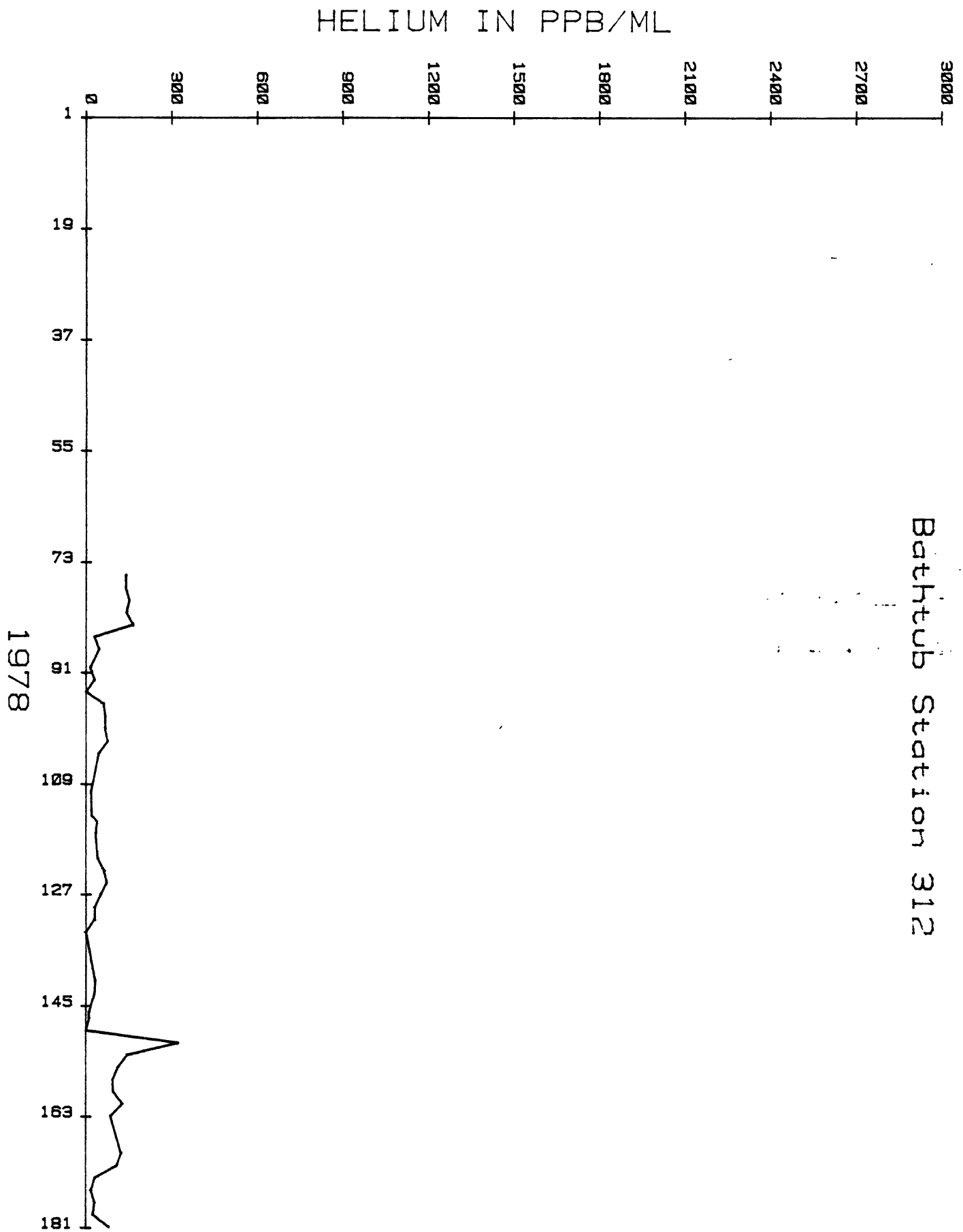

Figure 34.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, January through June, 1978.

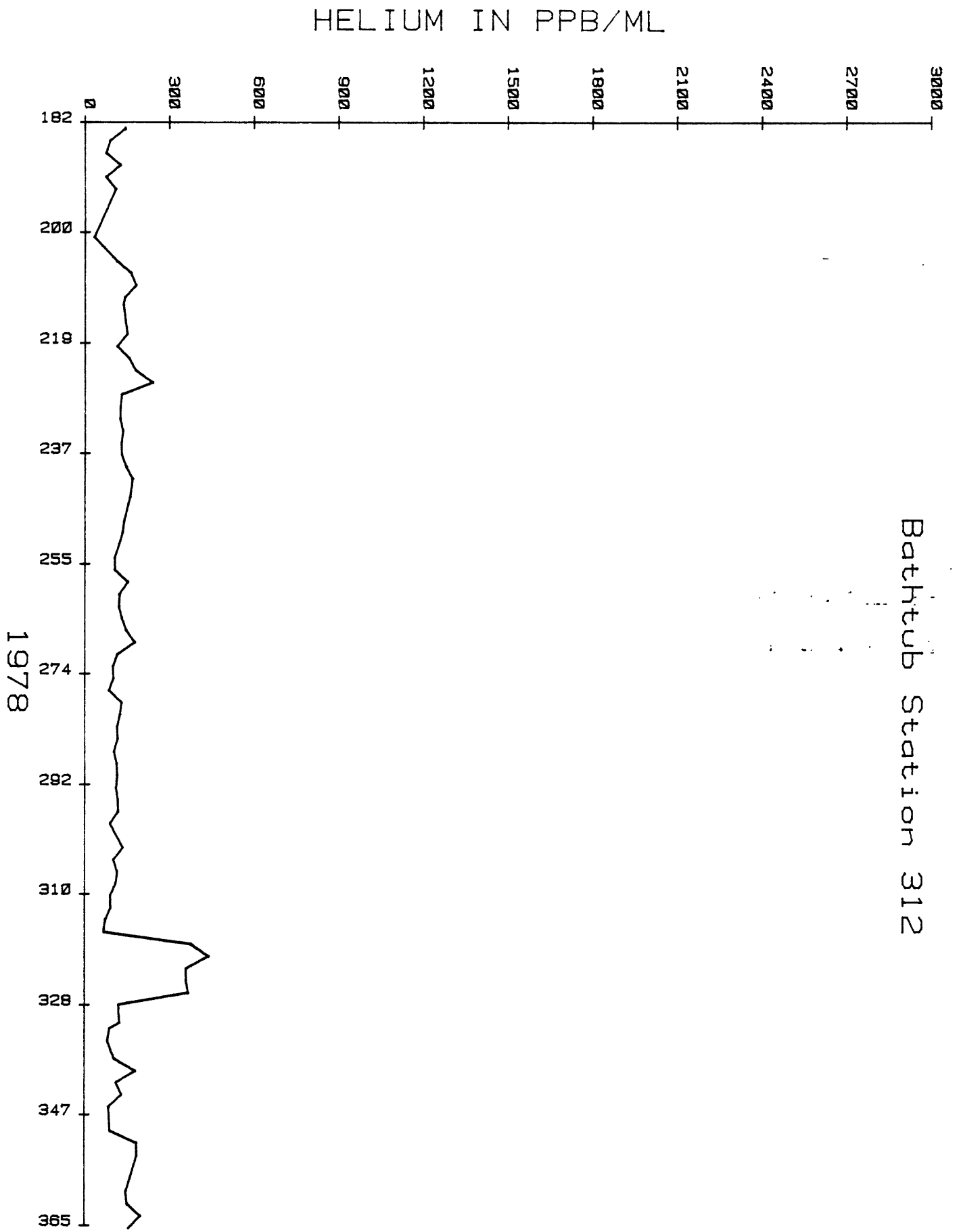

Figure 35.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, July through December, 1978.

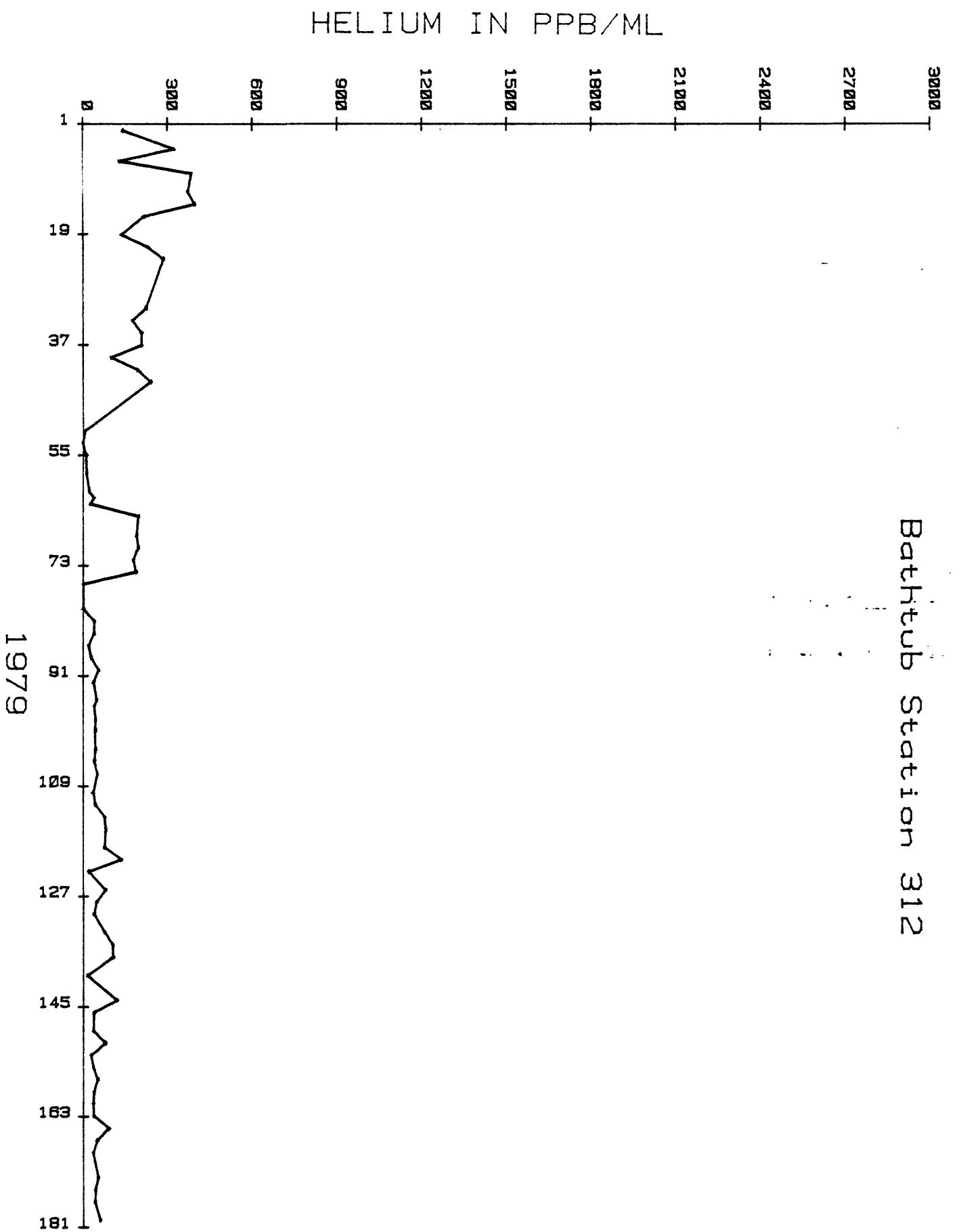

Figure 36.--Helium concentrations in water samples, Yellowstone National Park, Wyoming, January through June, 1979.

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 37.--Chart showing correlation of Julian and Gregorian calendar.