

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 V - Jan. 1 - Dec. 31, 1982

by

W. P. Doering and Irving Friedman

Open-File Report 83-500

1983

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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

Part V - January 1 - December 31, 1982

The purpose of this report of a continuing project is to compare the relationship of changes in the helium content of natural water wells and springs and the occurrence of earthquakes. Bulashevich and Bashorin (1974) reported marked changes of helium in wells preceding an earthquake which suggests that this technique may be employed to predict earthquakes. Work on this project in previous years is described by Doering and others (Doering and Friedman, 1980a, 1980b, 1982, and Doering and others, 1981).

We received and analyzed for helium water samples from fourteen wells or springs located northwest of Yellowstone National Park and also samples from six wells in the Imperial Valley of southern California. These stations are located in the Hebgen Lake area of Montana and the Imperial Valley in California and were selected because they are in active seismic regions. Samples from six stations were received for only part of 1982. Table 1 is a brief description of the twenty sampling stations and Figures 1 and 2 are maps showing the approximate locations of these stations.

The sample collectors use a plastic syringe fitted with a stop to withdraw about 9 milliliters of spring or well water and then inject it into a partially evacuated glass collection tube. Usually a sample is collected each day. After five samples are collected they are mailed to the Geological Survey laboratory at the Denver Federal Center, where the gas in the ullage space above the water in the sample tube is extracted and analyzed mass spectrometrically for its helium content. The method of analysis is given in Doering and others, 1981.

The analytical precision is  $\pm 5\%$ . An additional  $\pm 15\%$  error is due to variations in the stations due to temperature variations, amount of water collected, and the method and daily time of sample collection. At the stations that are wells just prior to collection there may have been a large flow of water and at other stations no water was being used. There seems to be more uniform data from the stations that are free flowing springs. These springs are stations 307, 310, 313, 314, and 318. The total precision of collection and analysis is about  $\pm 20\%$ . The daily record of the amount of helium present at each station is shown on Figures 3 through 22. Since there are large concentration differences of helium from the stations four scales are used to report the data. Numerical Julian dates are given on these graphs. These dates can be converted to the regularly used calendar dates by using Figure 23.

The National Earthquake Information Service reported twenty-four earthquakes having a magnitude of 3 or greater that occurred in the reporting regions during 1982. Table 2 lists the date, epicenter location and magnitude of the two quakes in the Imperial Valley and the three quakes in southwest Montana having a magnitude of greater than 4.0. These quakes are indicated by tick marks and labeled "EQ" on the dates of occurrence on the graphs of Figures 3 through 22. The most notable observations are described below.

At station 301 there was a sudden decrease in helium on day 280, which is 14 days before the first of three earthquakes beginning on day 294. Earthquakes also occurred on days 299 and 308. The helium content from this station remained low until about day 297 when it gradually increased. However, on day 117 there was a sudden helium decrease that continued for fifty days. This indicates that the decrease beginning on day 208 may not be related to the three earthquakes.

At Thexton Hot Springs, station 318, there was a large helium increase on day 282, which is 12 days before the three earthquakes beginning on day 294. From that date until day 311 the helium content decreased rapidly. After day 311 the average helium content remained constant.

At station 344 there was a sudden helium decrease on day 77, which is four days before the earthquake on day 81. The average helium content remained low until day 96 when it returned to higher values.

At station 349 the helium content began a large decrease on day 210 and continued to decrease through day 217 which is 31 days before the earthquake on day 248. After day 219 the helium content gradually increased through day 250. However there are other similar helium changes.

These graphs depict a number of anomalies that are not related to earthquakes. The large variations shown on station 305 was due to changing the source and method of collection. The sudden decrease of helium after about day 146 from station 316 is difficult to explain. This station shows the same sudden changes in May and November, 1981 (Doering and Friedman, 1982) and 1982. This may be due to changes in the aquifer due to irrigation. The wide variations on station 343 are also unexplainable and the incomplete record does not contribute to finding a cause. There are large excursions from the average for one day on stations 318, 321, and 349. These do not appear to be related to earthquakes.

This project is being continued to monitor helium. There were no large earthquakes in 1982 so there is no conclusive evidence that there is a relation of earthquakes to helium changes. We thank the collectors for their faithfulness in sending in the water samples from the springs and wells.

Table 1.--Localities of helium-sampling stations

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

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

| Station No. | Station Name | Address  | Comments  |
|-------------|--------------|--|---|
| 316         | Blakeley     | Shirley Blakeley<br>Route 38<br>Box 2249<br>Livingston, MT 59047           | 119 m (390 ft) fully cased well.  |
| 317         | MacMillan    | Richard MacMillan<br>P. O. Box 761<br>Ennis, MT 59729                      | Domestic well, 42.7 m (140 ft) deep; 113.8 lpm (30 gpm) flow; water contains H <sub>2</sub> S; temp. is 53.3°C (128°F). |
| 318         | Thexton      | Alex Yenny<br>P. O. Box 748<br>Ennis, MT 59729                             | Thexton Hot Springs, water temp. is 84°C (183°F).   |
| 319         | Stands       | Mrs. Alvin Stands<br>Pray, MT 59065  | 68 m (223 ft) deep well; cased for 30.5 m (100 ft).   |
| 321         | Murphy       | Jim Murphy<br>Ox Yoke Ranch<br>Emigrant, MT 59027                          | 79.2 m (260 ft) deep well; perforated from 45.7-68.6 m (150-225 ft).  |
| 322         | Kamps        | George Kamps<br>Route 38<br>P. O. Box 2071<br>Livingston, MT 59047         | 33.5 m (110 ft) fully cased well.   |
| 343         | Blevins      | Roy Blevins<br>5605 Butters Road<br>Brawley, CA 92227                      | Old well of unknown depth, dug 50 years ago; temp. about 60°C (140°F).  |
| 344         | Bowles       | Mrs. Charles Bowles<br>Box 74<br>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).               |
| 345         | Hagen        | Julia Hagen<br>2190 East Titsworth Rd<br>Brawley, CA 92227                 | About 305 m (1000 ft) deep well; temp. is about 38°C (100°F).   |
| 347         | Jeska        | Johanna Jeska<br>Holt Ave. Store<br>5449 Butters Road<br>Brawley, CA 92227 | Old well of unknown depth; drilled in 1930's; fully cased.  |

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

| Station No. | Station Name | Address   | Comments  |
|-------------|--------------|---|---|
| 348         | White        | Mrs. Dorothy White<br>P. O. Box 184<br>Ocotillo, CA 92259 | 88.4 m (290 ft) deep well.                      |
| 349         | Rodia        | Jim Rodia<br>P. O. Box 86<br>Ocotillo, CA 92259           | 183 m (600 ft) deep well; temp. is 33°C (92°F). |

Table 2.--Earthquakes in reporting areas in 1982

| Julian date | Calendar date | Latitude N. | Longitude W. | Region                      | Magnitude |
|-------------|---------------|-------------|--------------|-----------------------------|-----------|
| 81          | March 22      | 33.05       | 116.22       | W. of Brawley, CA           | 4.5       |
| 248         | Sept 5        | 32.93       | 115.85       | W. of Brawley, CA           | 4.4       |
| 294         | Oct 21        | 44.76       | 111.79       | W. of W. Yellowstone,<br>MT | 4.3       |
| 299         | Oct 26        | 44.76       | 111.75       | W. of W. Yellowstone,<br>MT | 4.6       |
| 308         | Nov 4         | 44.77       | 111.75       | W. of W. Yellowstone,<br>MT | 4.2       |

## REFERENCES

- Bulashevich, Yu. P., and Bashorin, V. N., 1974, Combined use of helium surveying and seismic methods in the study of fault tectonics: *Geologiya; geofisika*, v. 15, p. 101-104.
- 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.
- Doering, W. P., Friedman, I., and Veronda, G., 1981, Survey of helium in natural water wells and springs in southwest Montana and vicinity and Imperial Valley, California, Part III-Jan. 1-Dec. 31, 1980: U. S. Geological Survey Open-File Report 81-893, 58 p.
- Doering, W. P. and Friedman, I., 1982, Survey of helium in natural water wells and springs in southwest Montana and vicinity and Imperial Valley, California, Part IV-Jan. 1-Dec. 31, 1981: U. S. Geological Survey Open-File Report 81-486, 33 p.
- U. S. Geological Survey, 1982, Preliminary determination of epicenters, No. 12-82 April 14, 1982, No. 36-82 Sept. 29, 1982, No. 42-82 Nov. 10, 1982, No. 43-82 Nov. 17, 1982, No. 44-82 Nov. 24, 1982: U. S. Geological Survey National Earthquake Information Service.

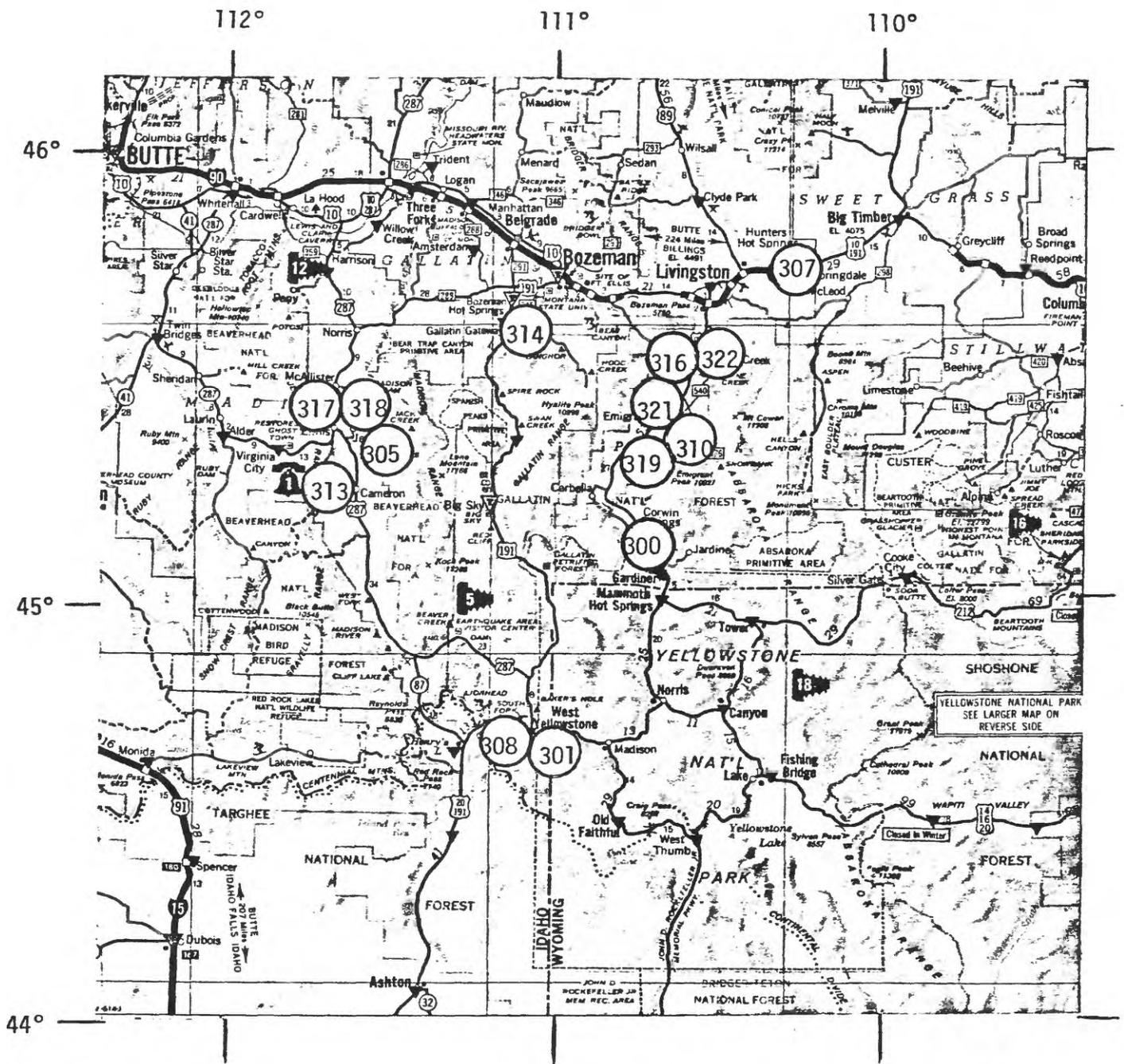


Figure 1.--Helium sampling stations (shown by number) in Montana.  
 Scale approximately 1:1,550,000 (1 inch to 24.6 miles).

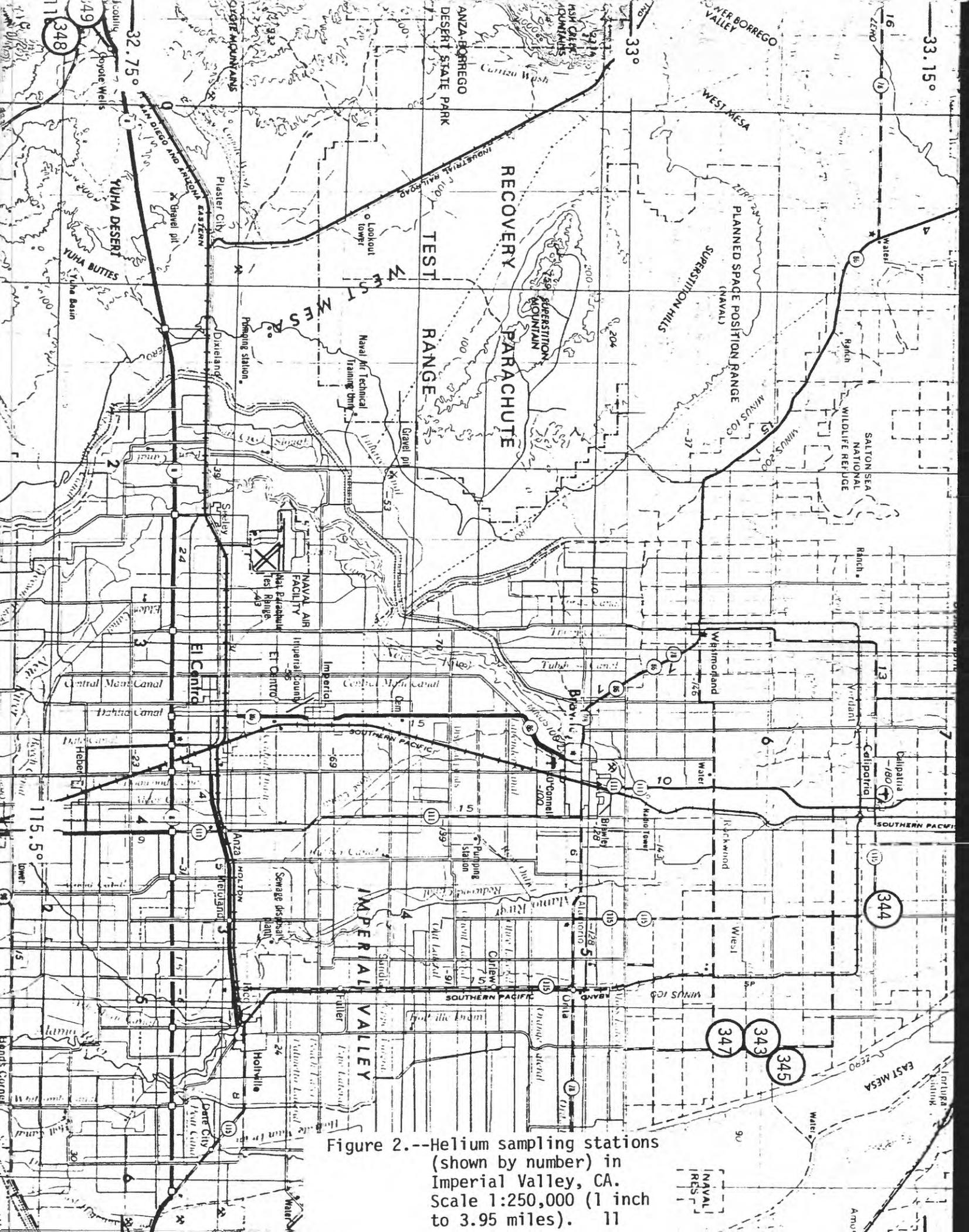


Figure 2.--Helium sampling stations (shown by number) in Imperial Valley, CA. Scale 1:250,000 (1 inch to 3.95 miles). 11

# HELIUM IN PPM/ML

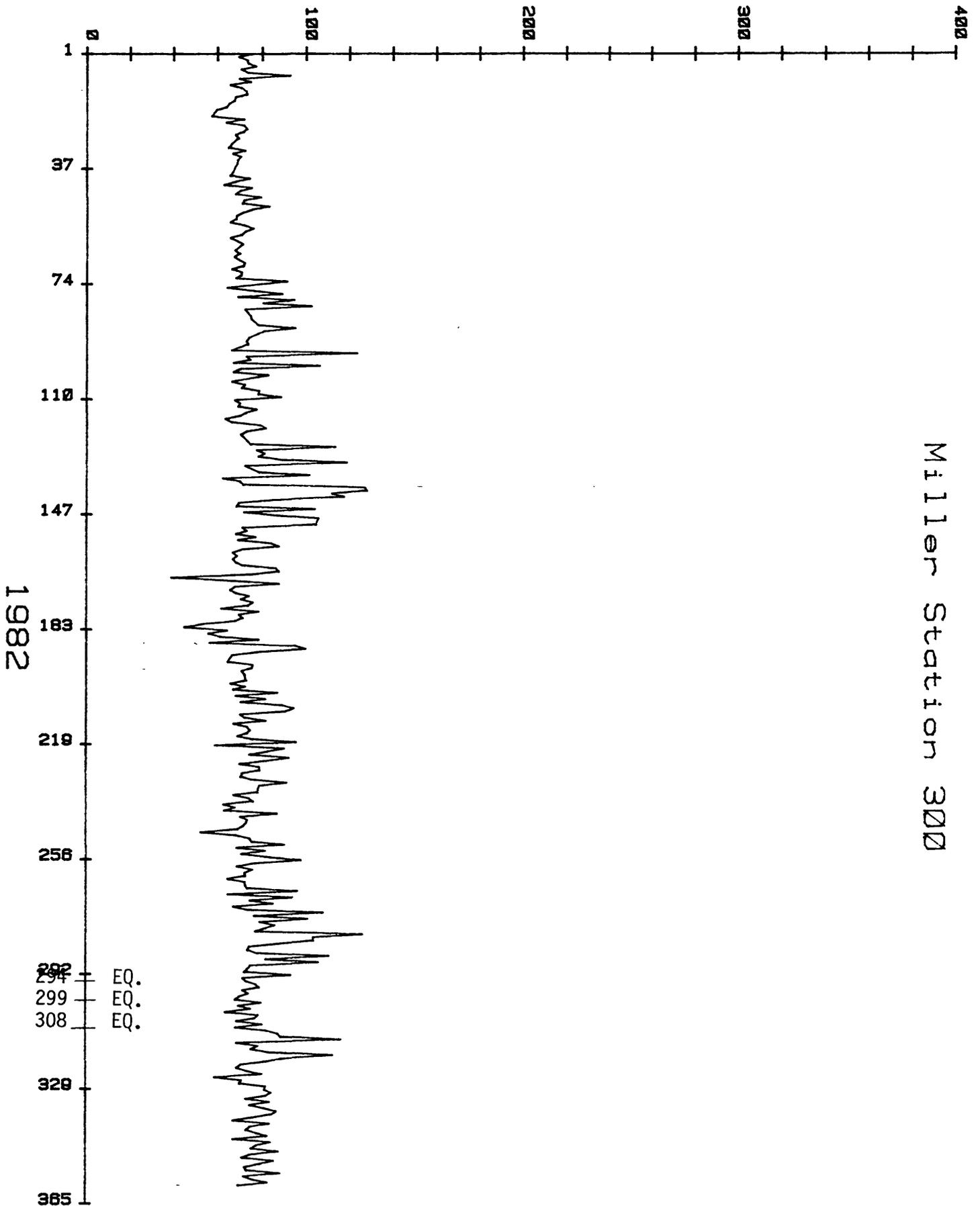
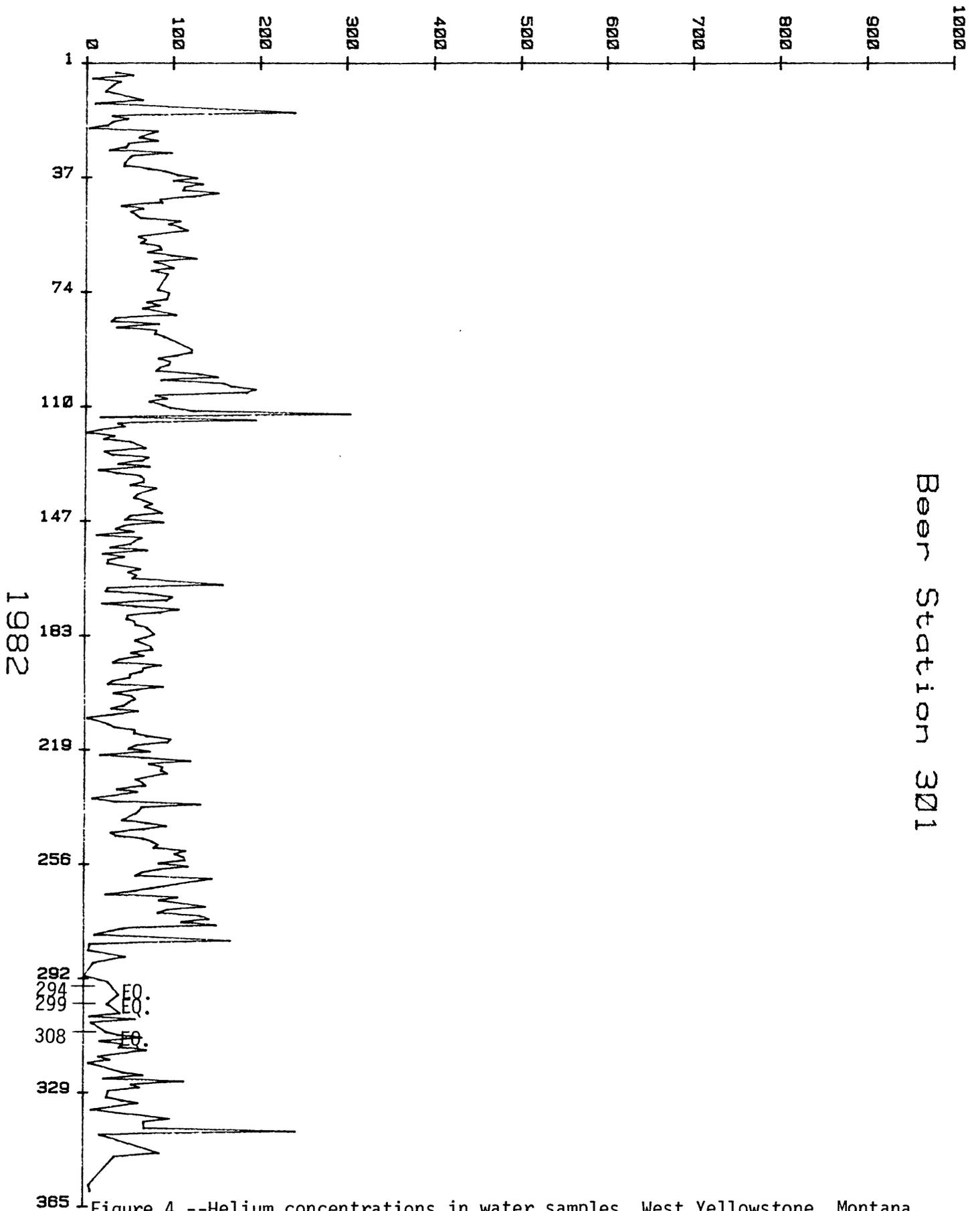


Figure 3.--Helium concentrations in water samples, Gardiner, Montana.

# HELIUM IN PPB/ML



Beer Station 301

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

# HELIUM IN PPB/ML

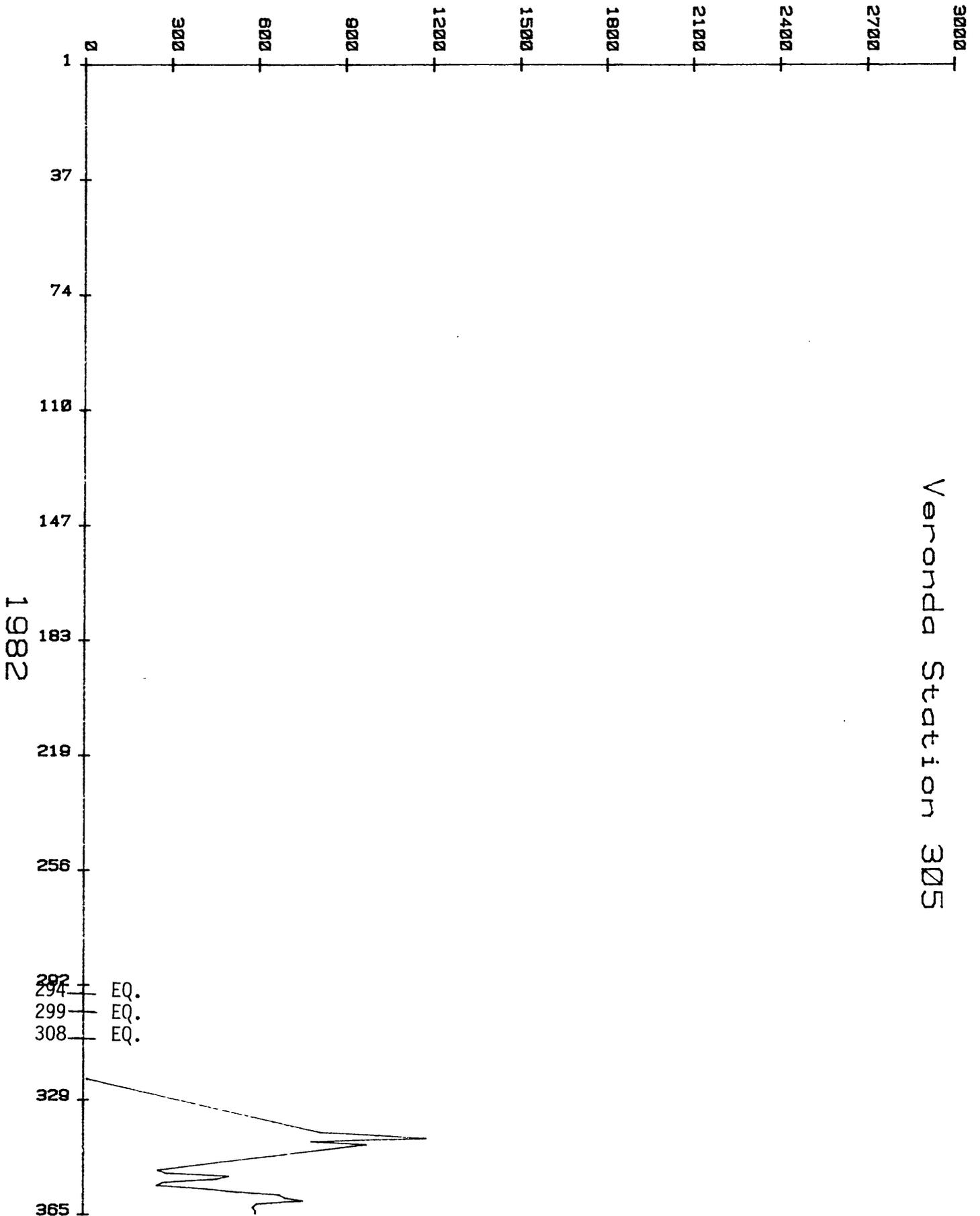


Figure 5.--Helium concentrations in water samples, Ennis, Montana.

# HELIUM IN PPM/ML

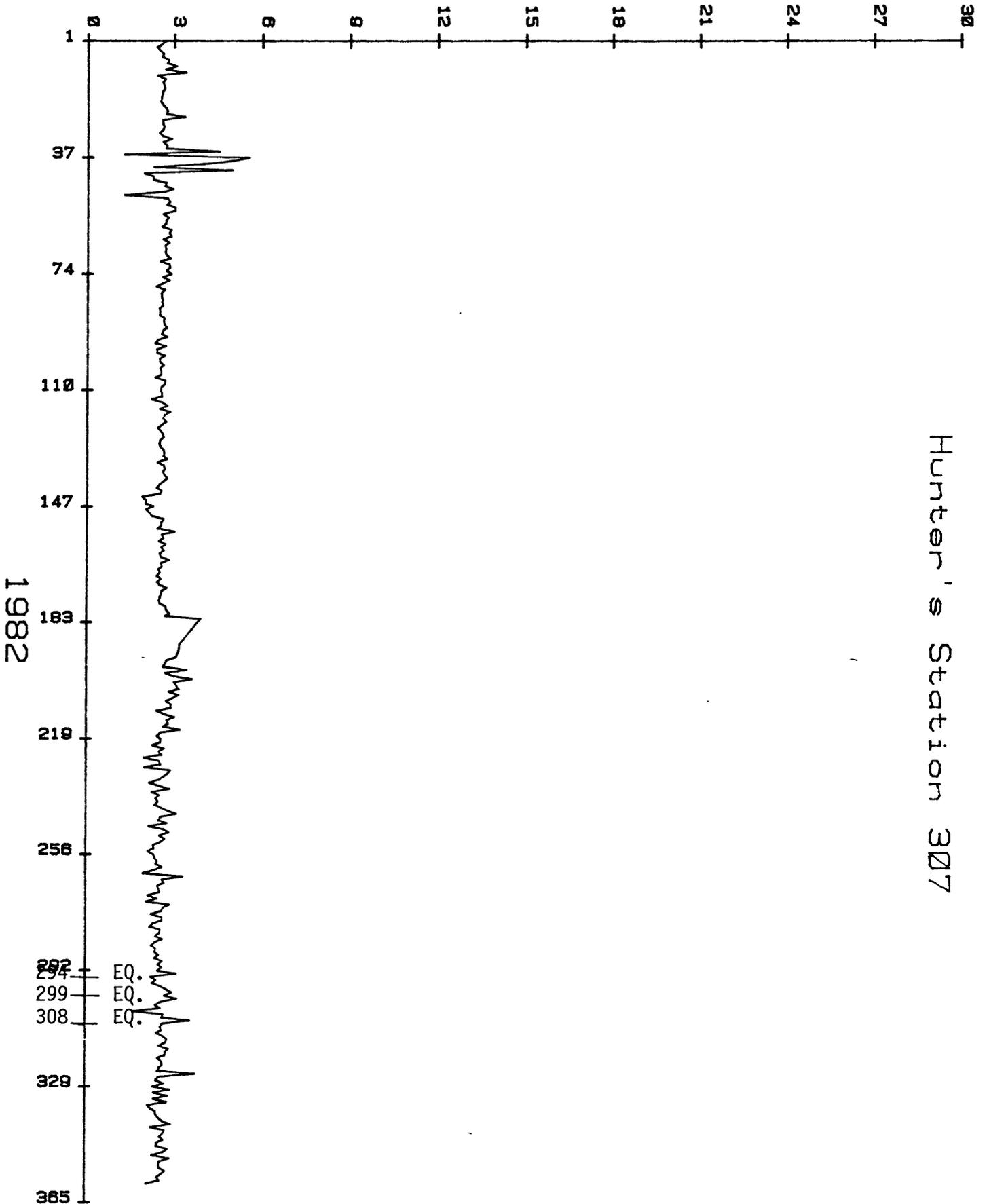


Figure 6.--Helium concentrations in water samples, Springdale, Montana.

# HELIUM IN PPB/ML

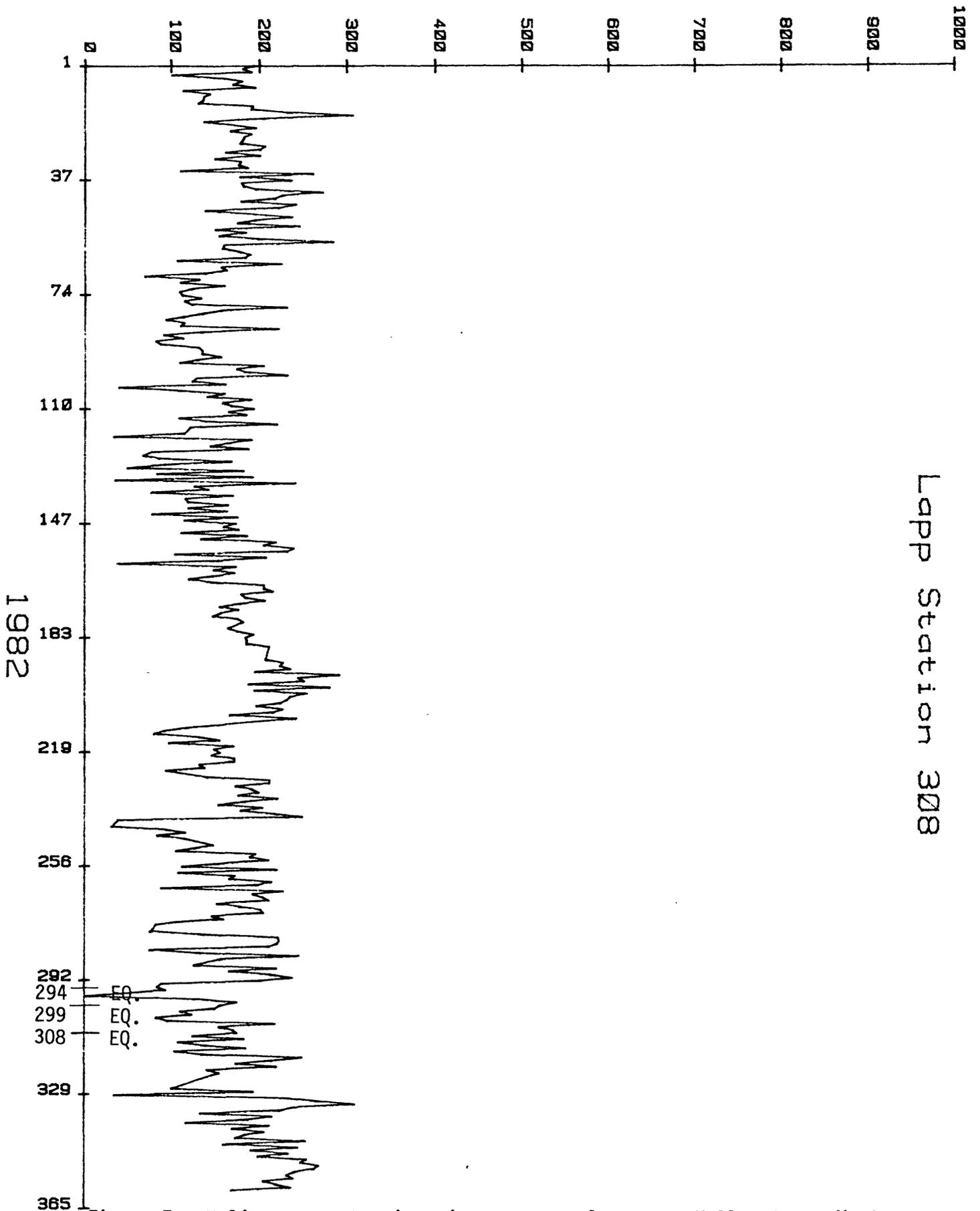
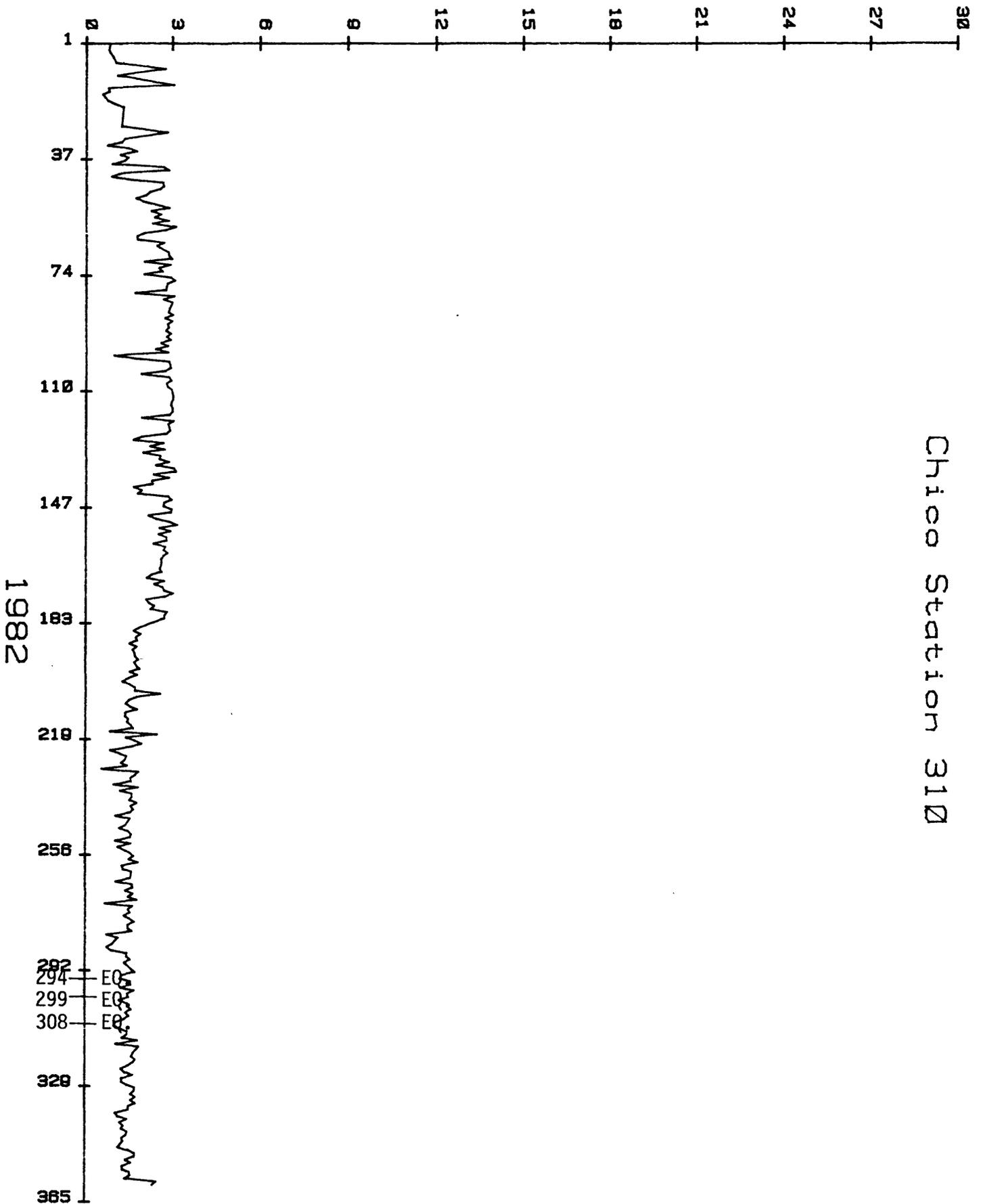


Figure 7.--Helium concentrations in water samples, West Yellowstone, Montana.

# HELIUM IN PPM/ML



Chico Station 310

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

# HELIUM IN PPB/ML

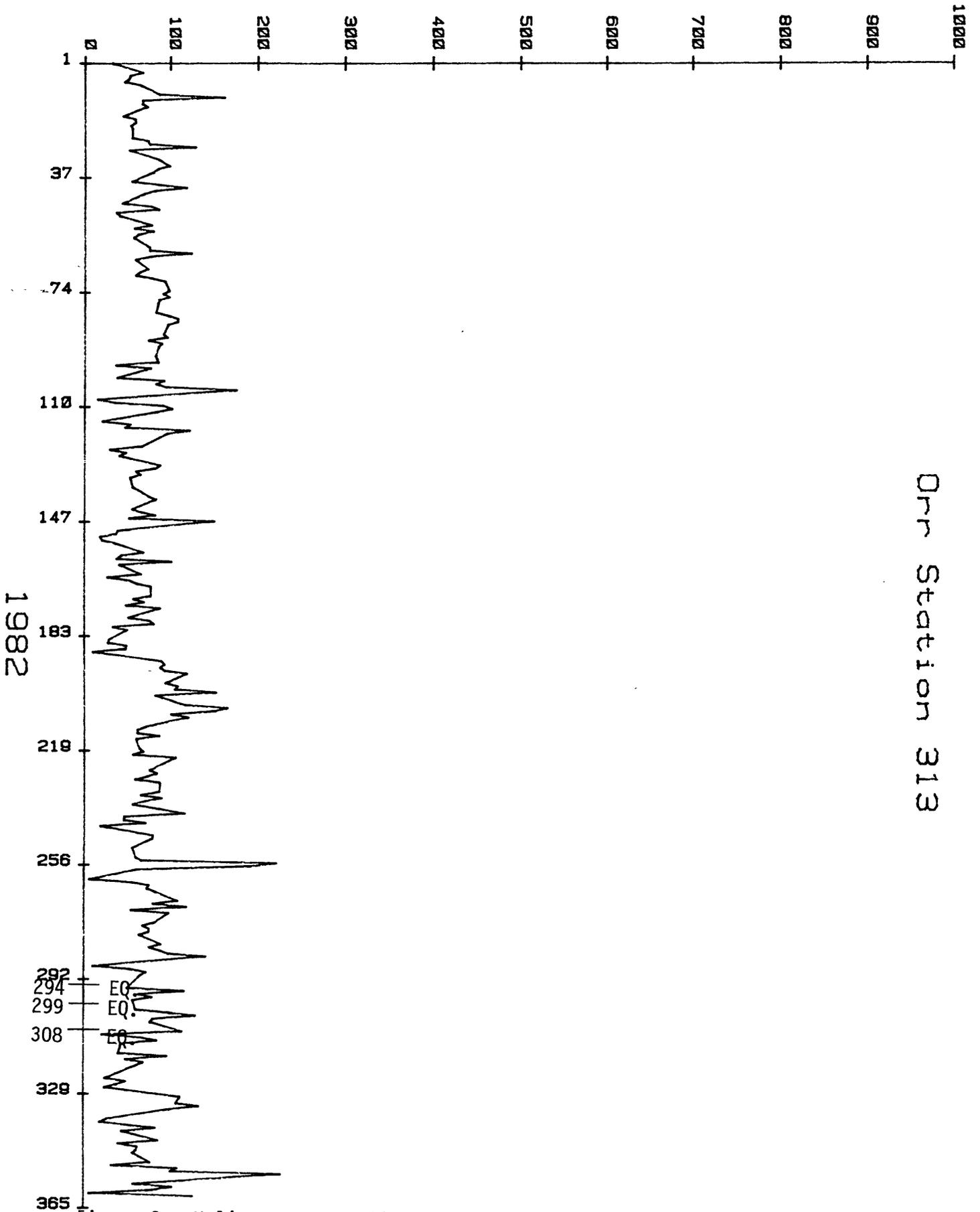
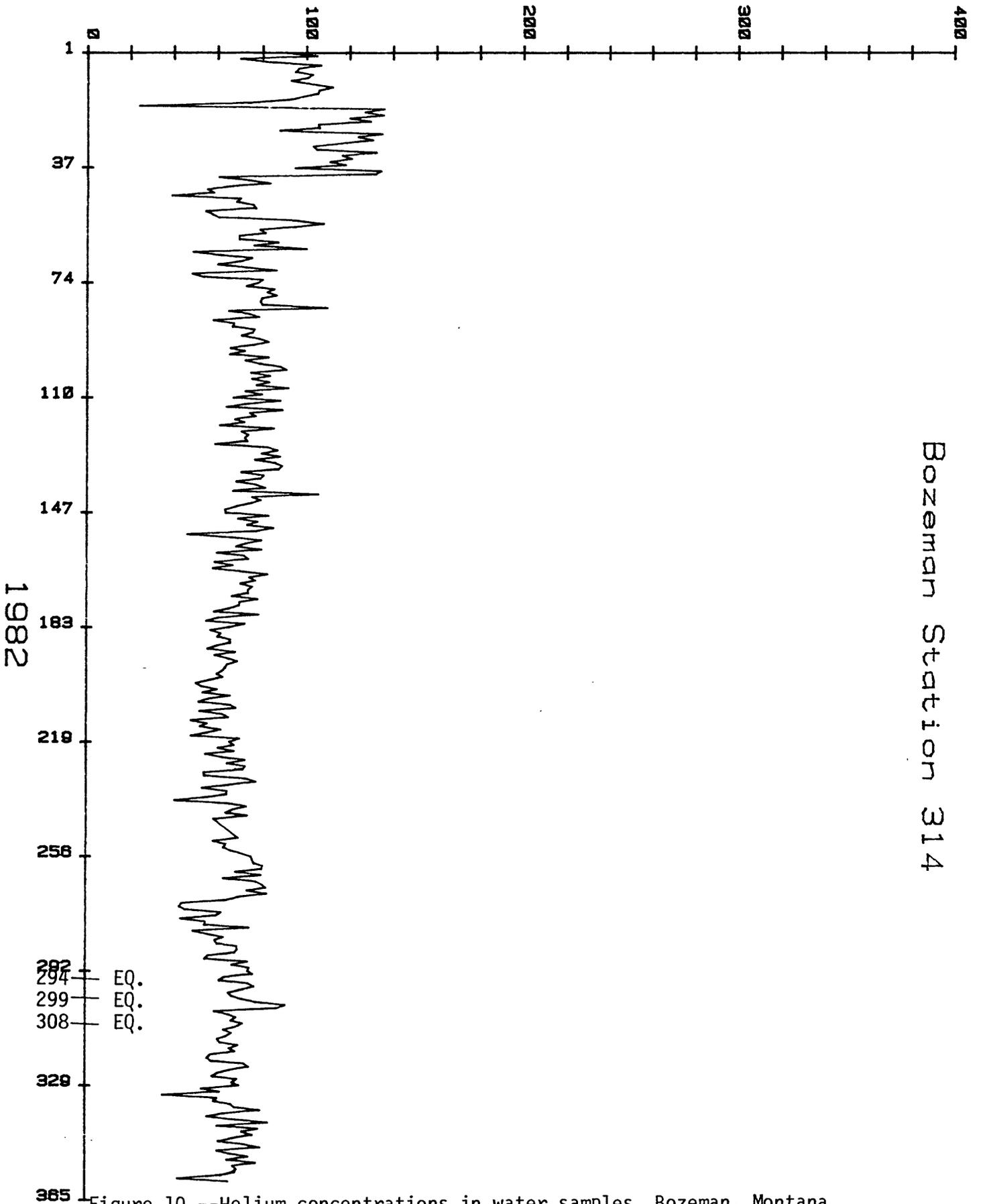


Figure 9.--Helium concentrations in water samples, Ennis, Montana.

# HELIUM IN PPM/ML



Bozeman Station 314

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

# HELIUM IN PPB/ML

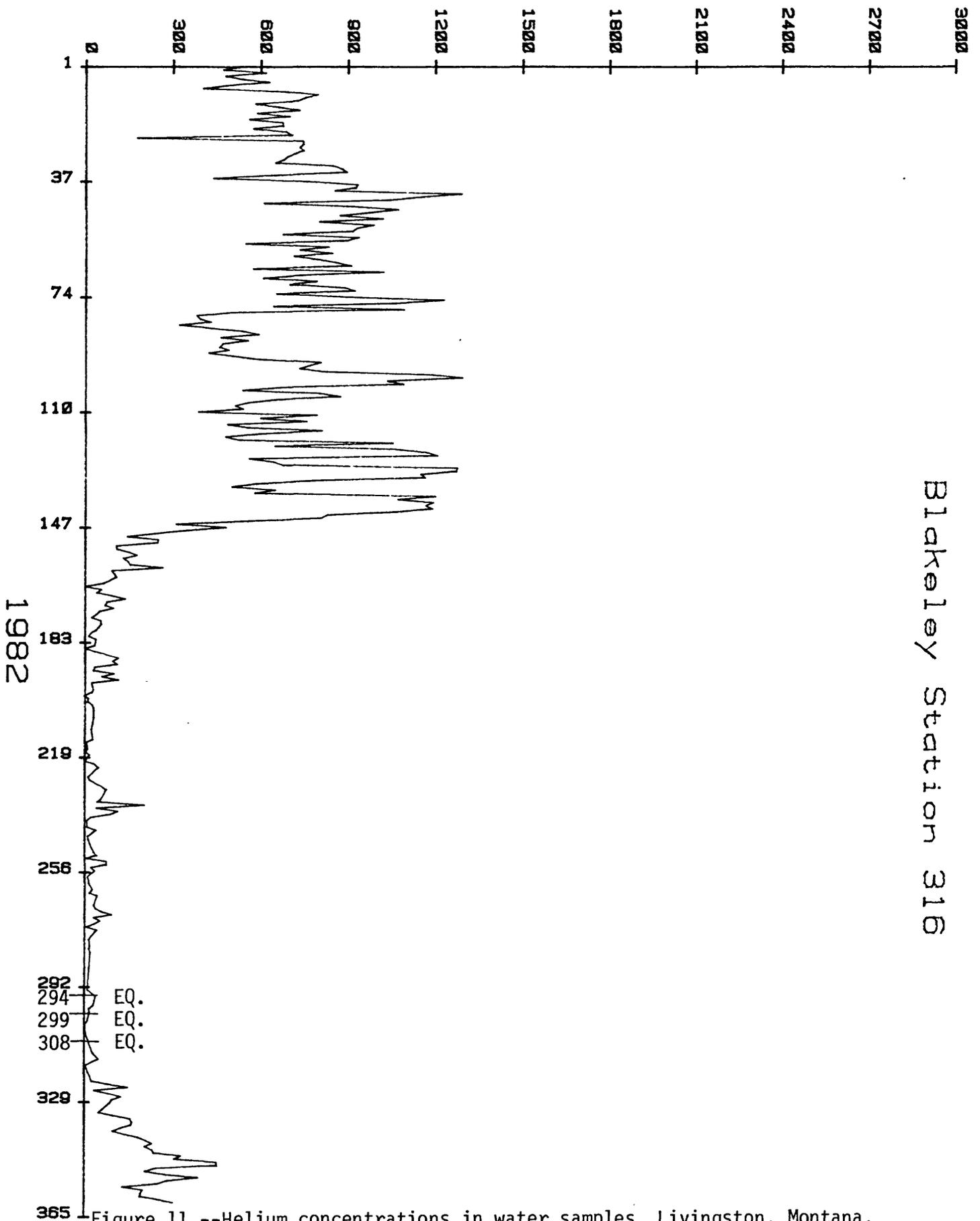


Figure 11.--Helium concentrations in water samples, Livingston, Montana.

# HELIUM IN PPM/ML

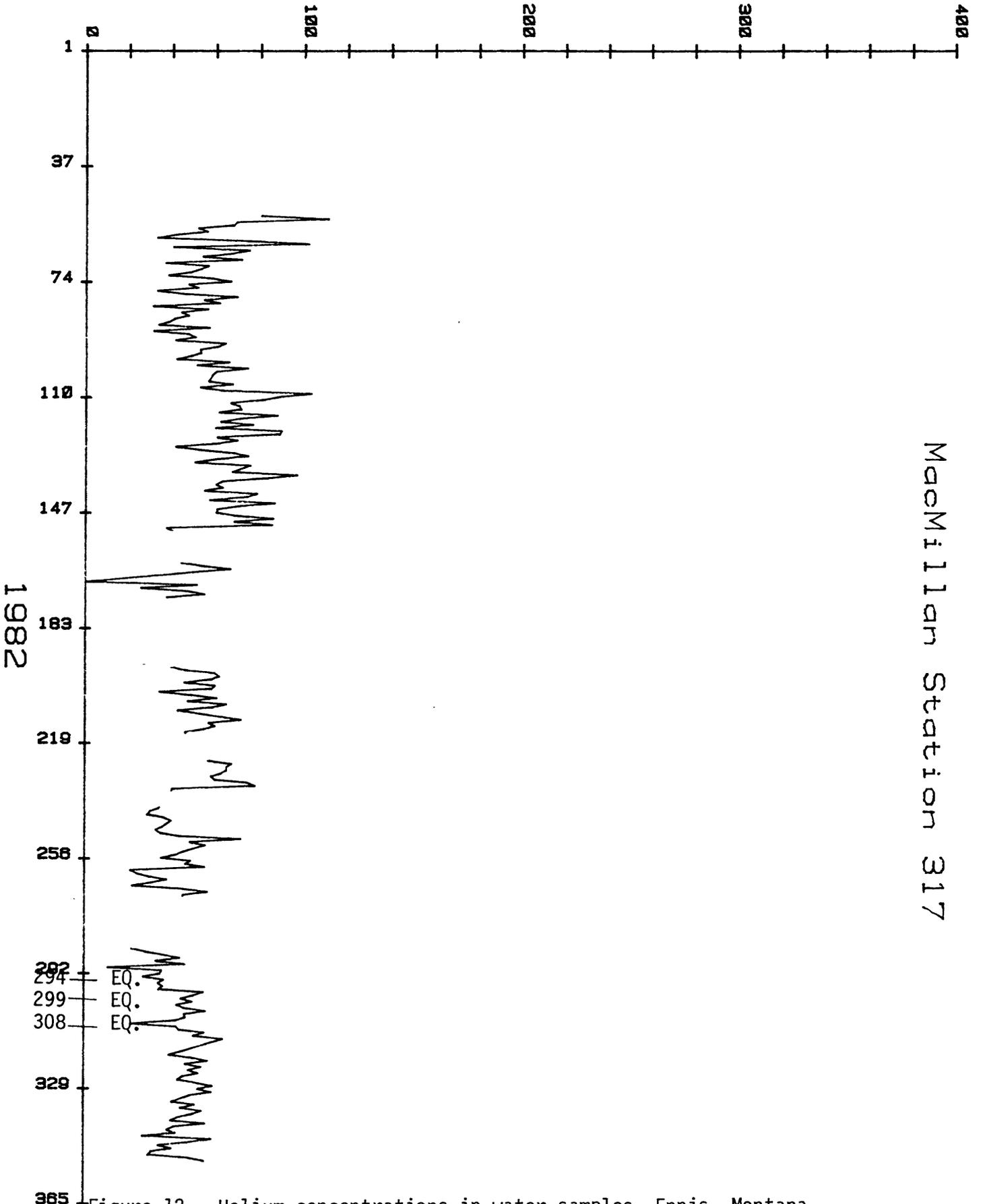
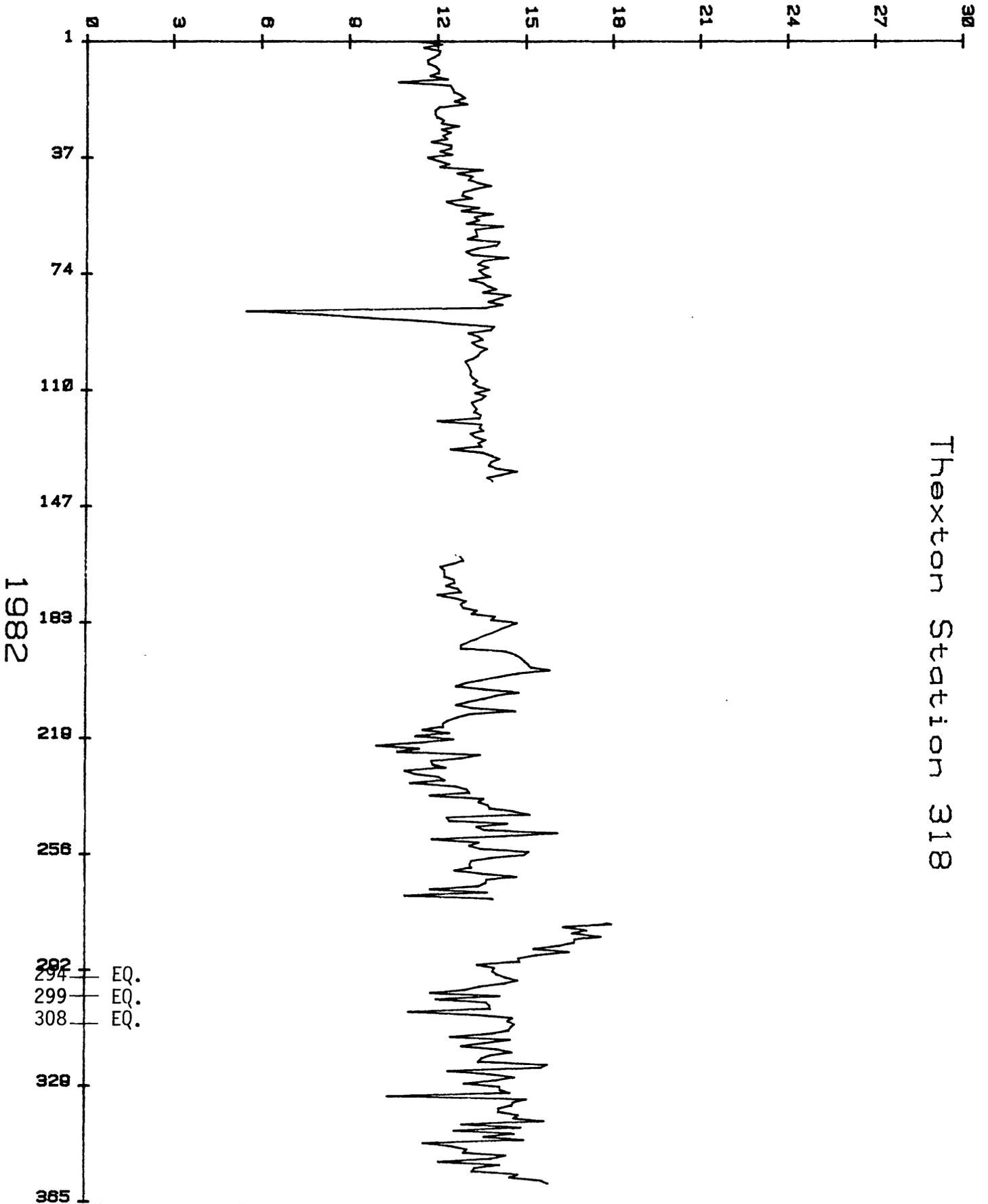


Figure 12.--Helium concentrations in water samples, Ennis, Montana.

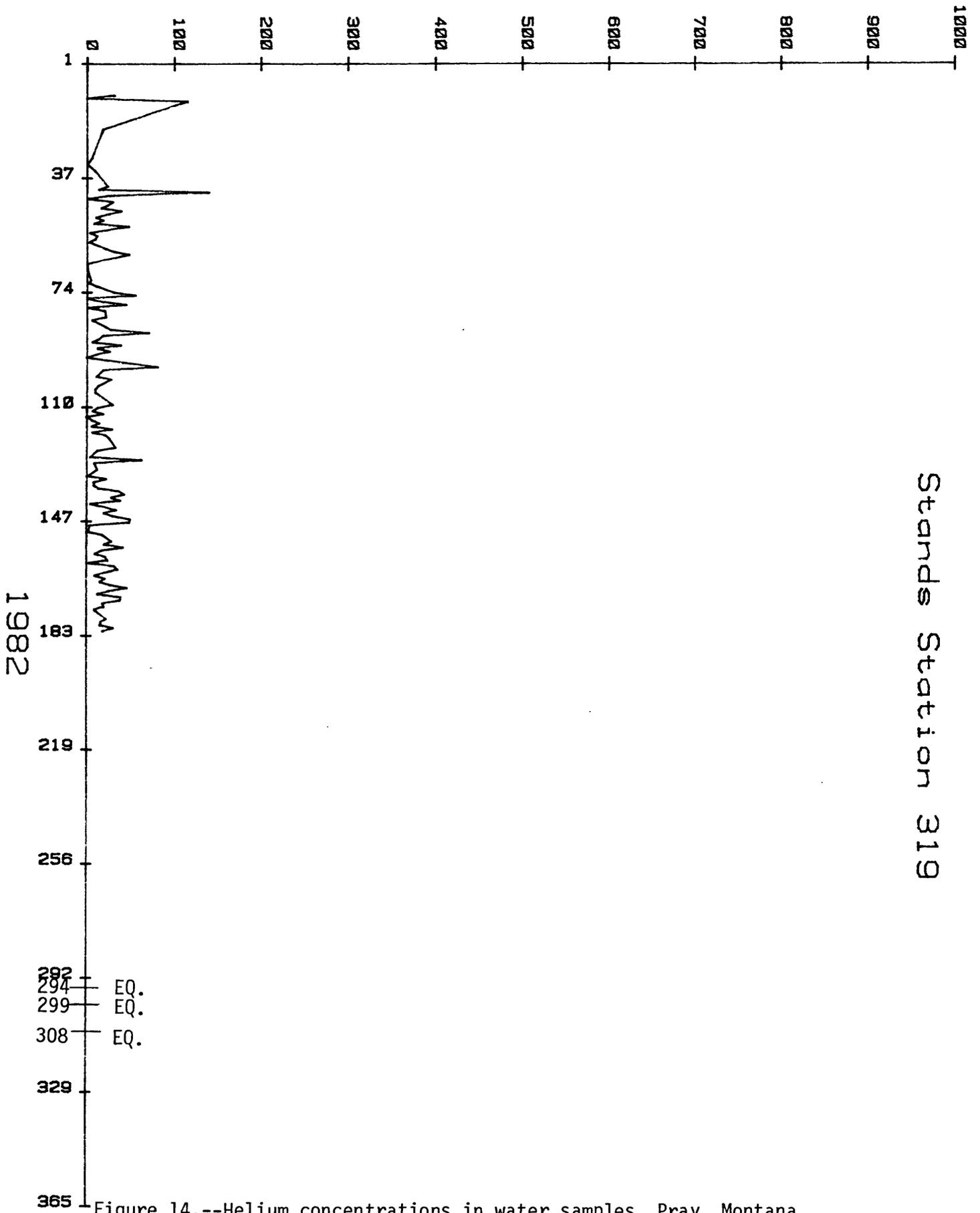
# HELIUM IN PPM/ML



Thexton Station 318

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

# HELIUM IN PPB/ML



Standards Station 319

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

# HELIUM IN PPB/ML

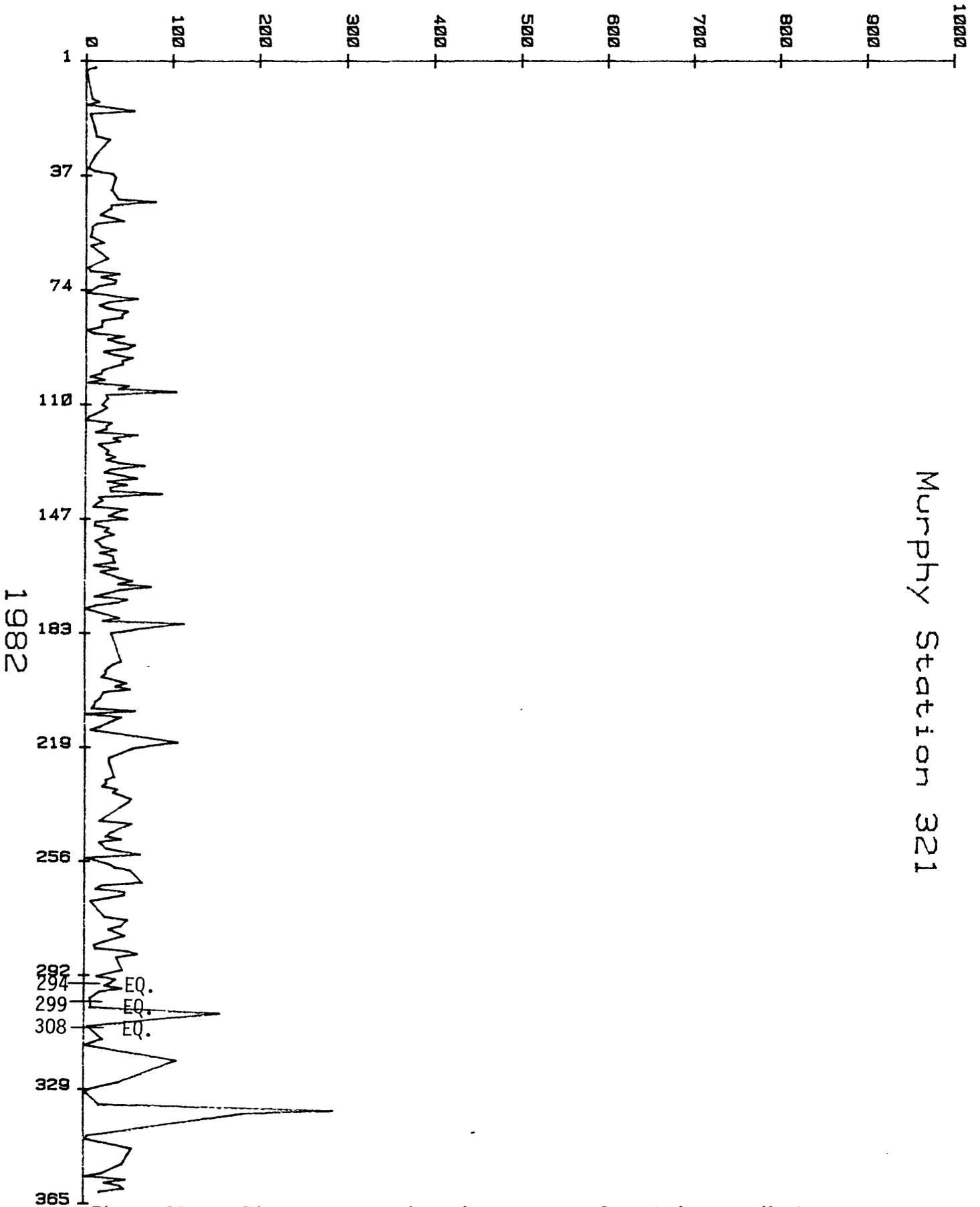
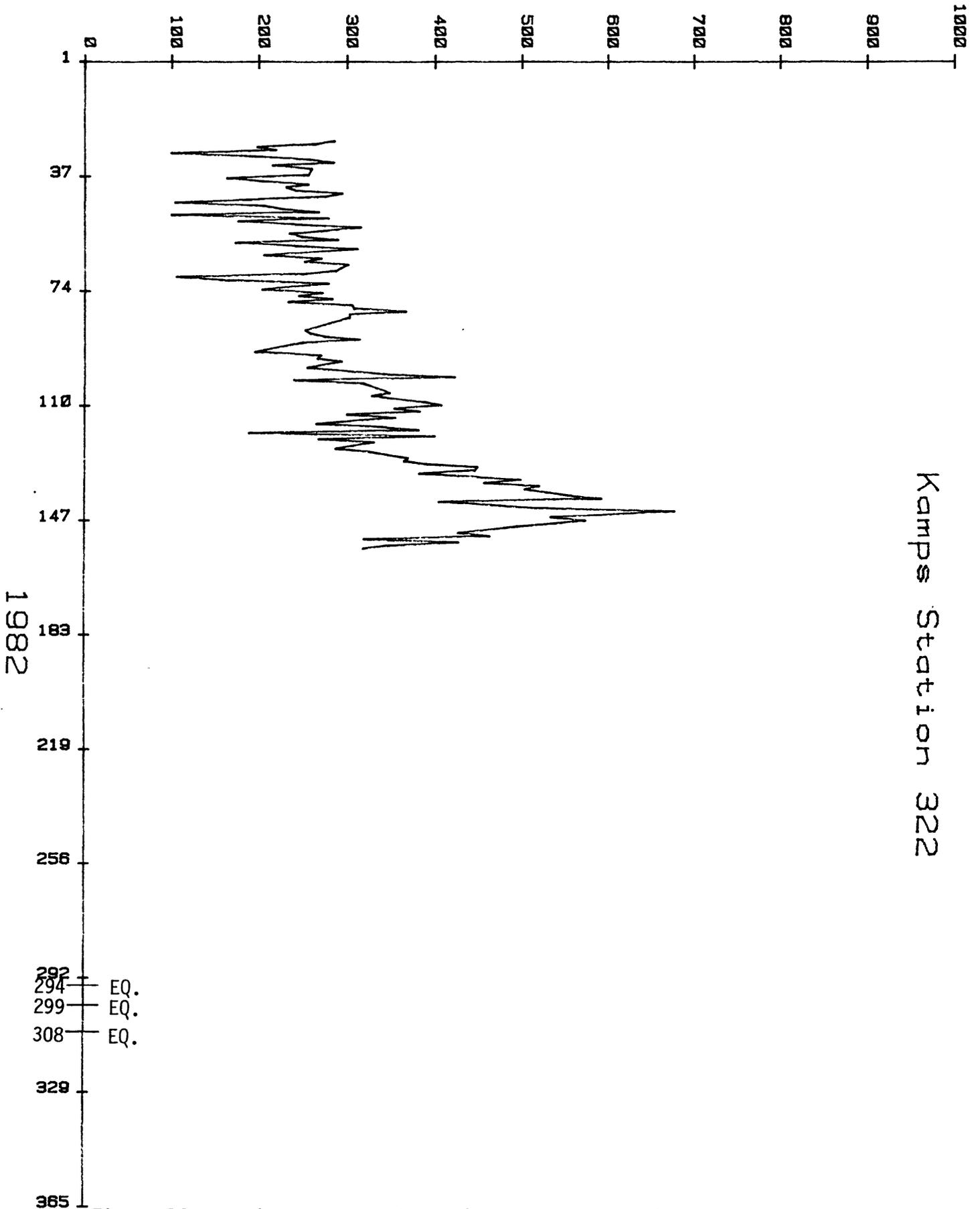


Figure 15.--Helium concentrations in water samples, Emigrant, Montana.

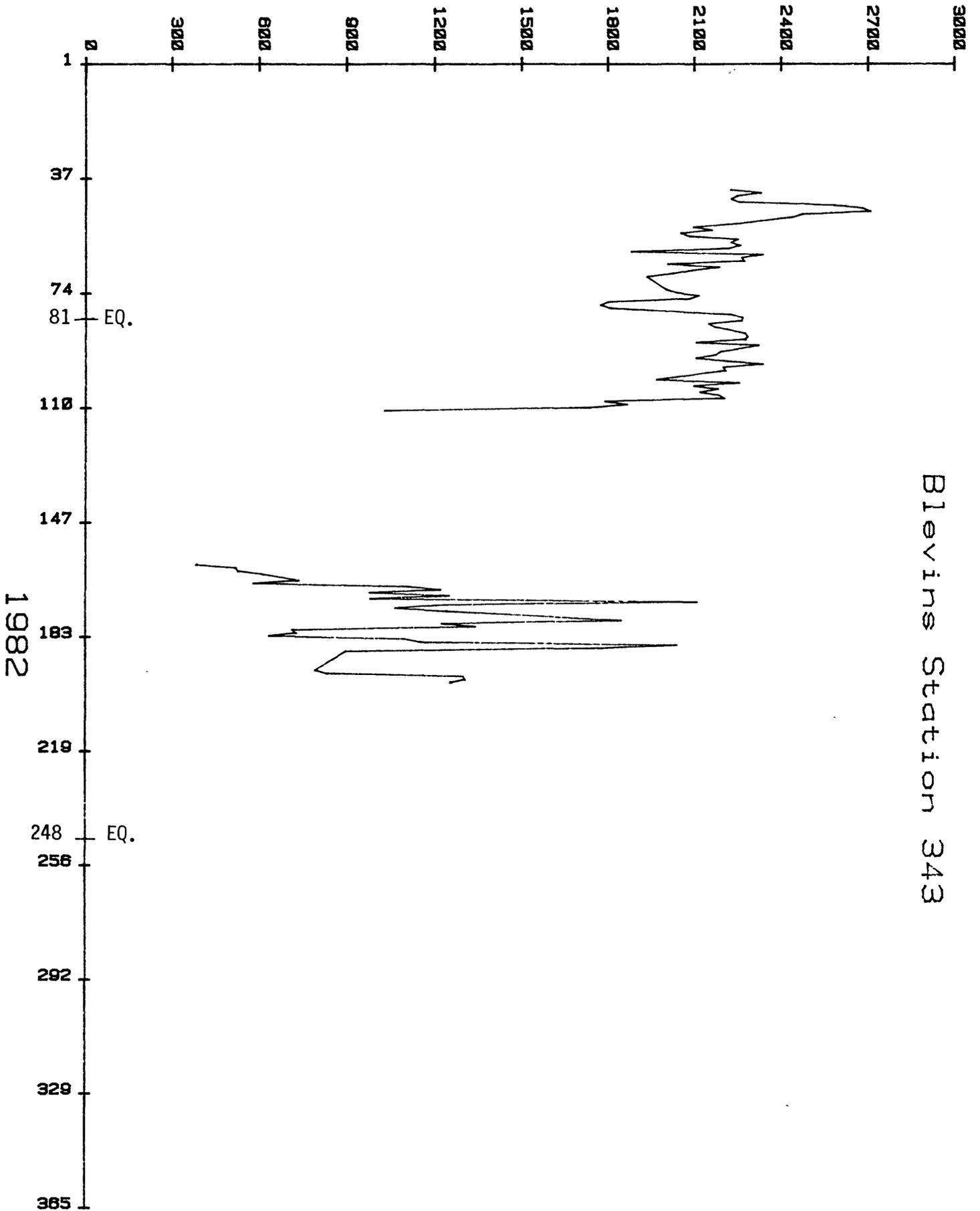
# HELIUM IN PPB/ML



Kamps Station 322

Figure 16.--Helium concentrations in water samples, Livingston, Montana.

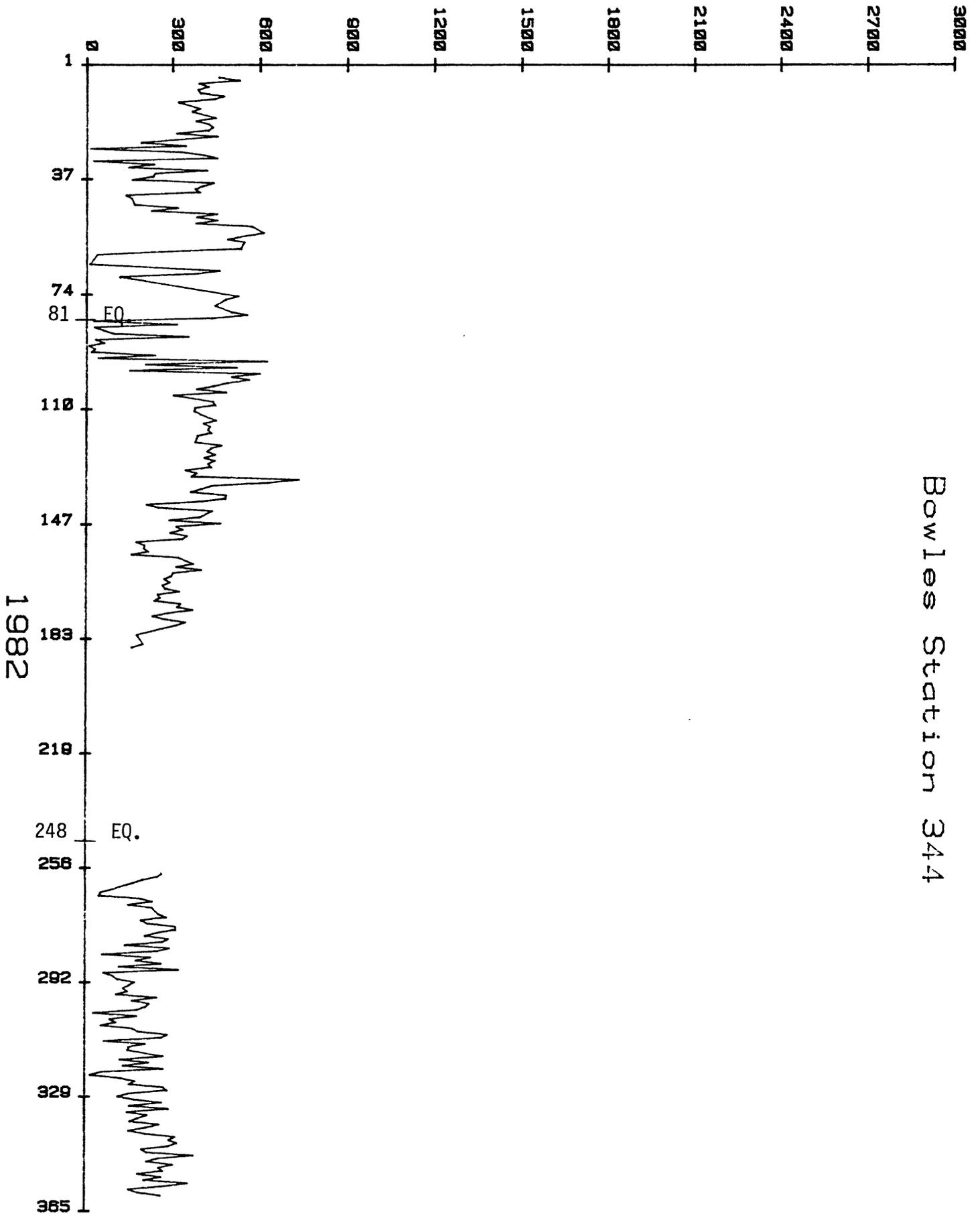
# HELIUM IN PPB/ML



Blevins Station 343

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

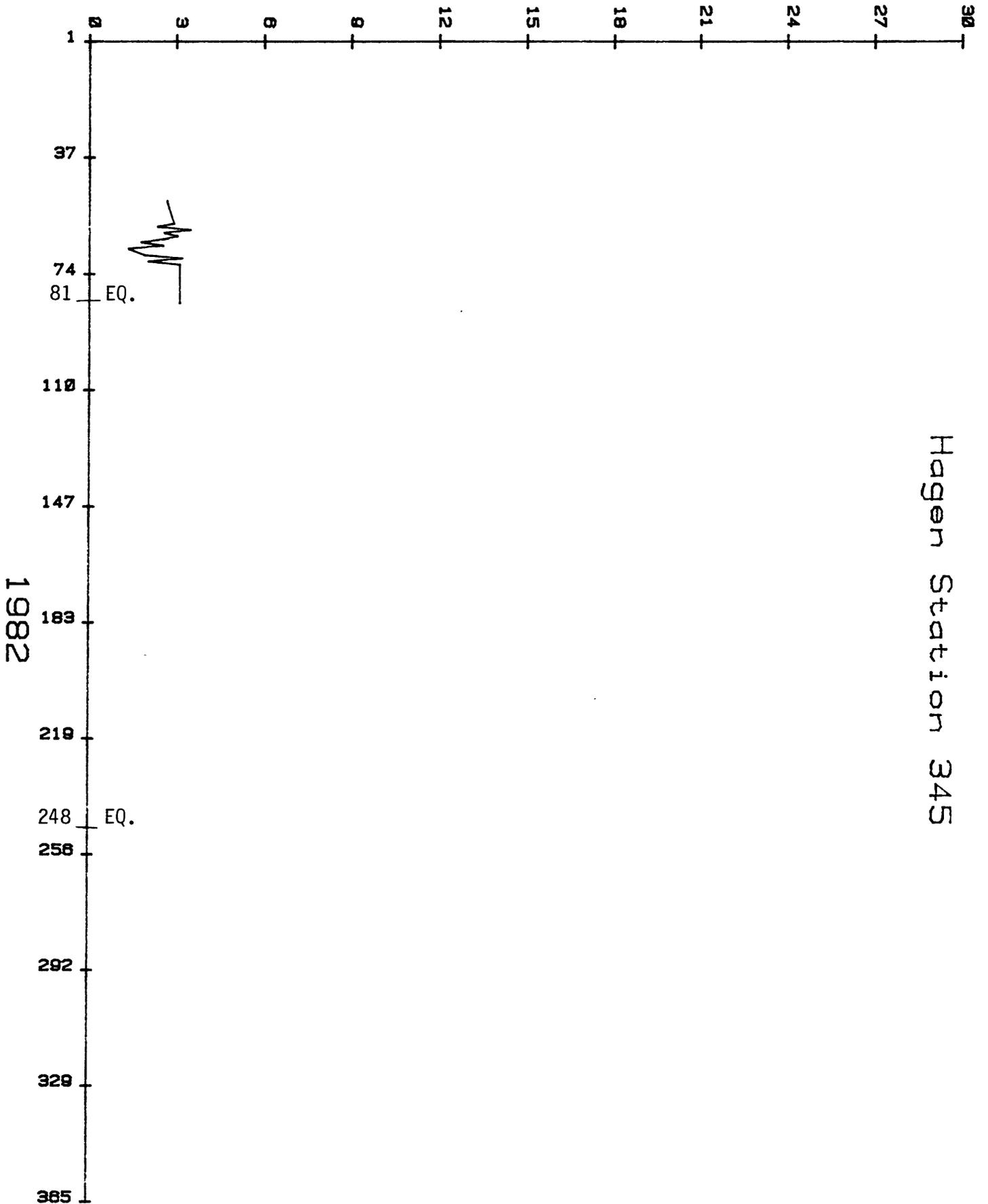
# HELIUM IN PPB/ML



Bowles Station 344

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

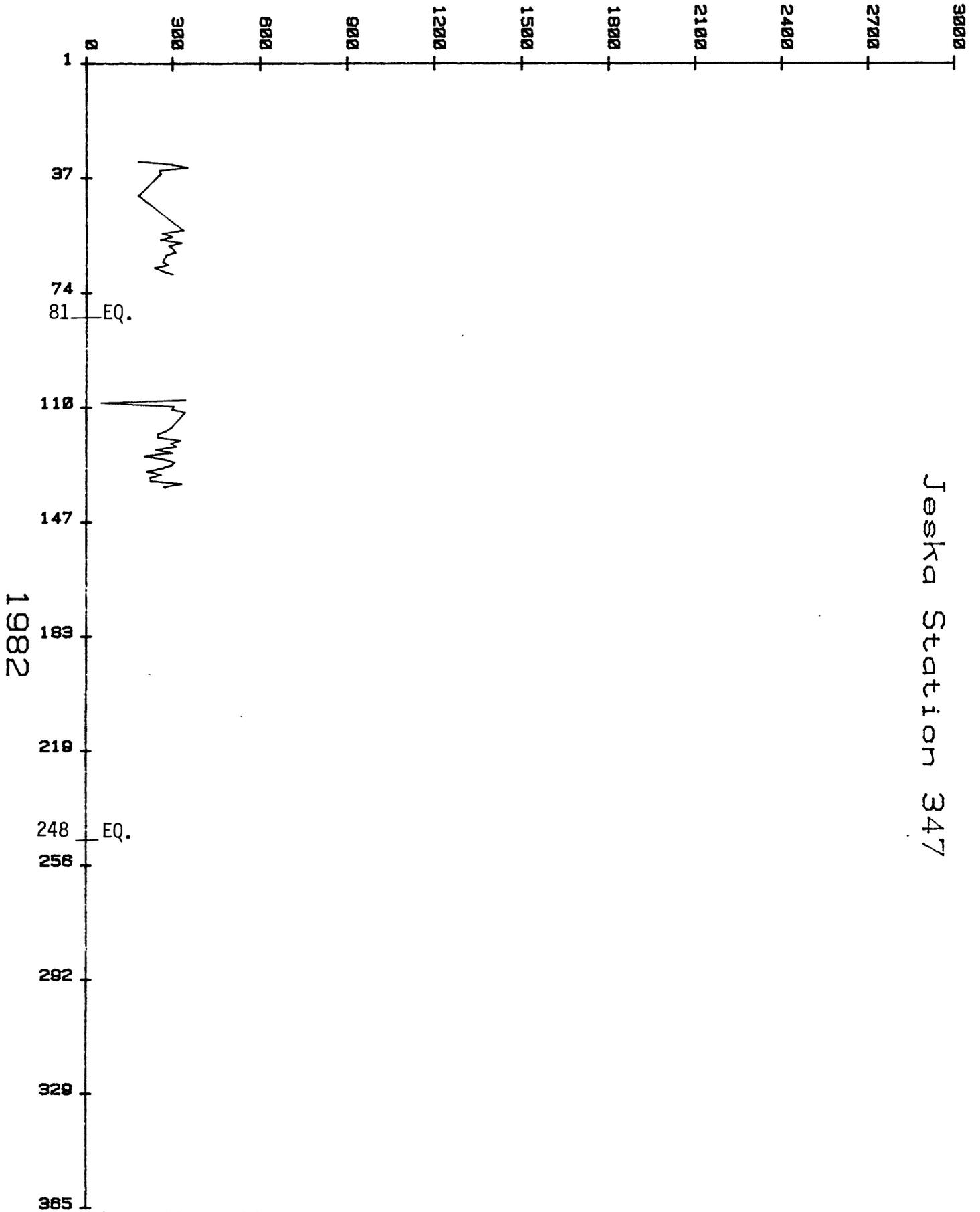
# HELIUM IN PPM/ML



Hagen Station 345

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

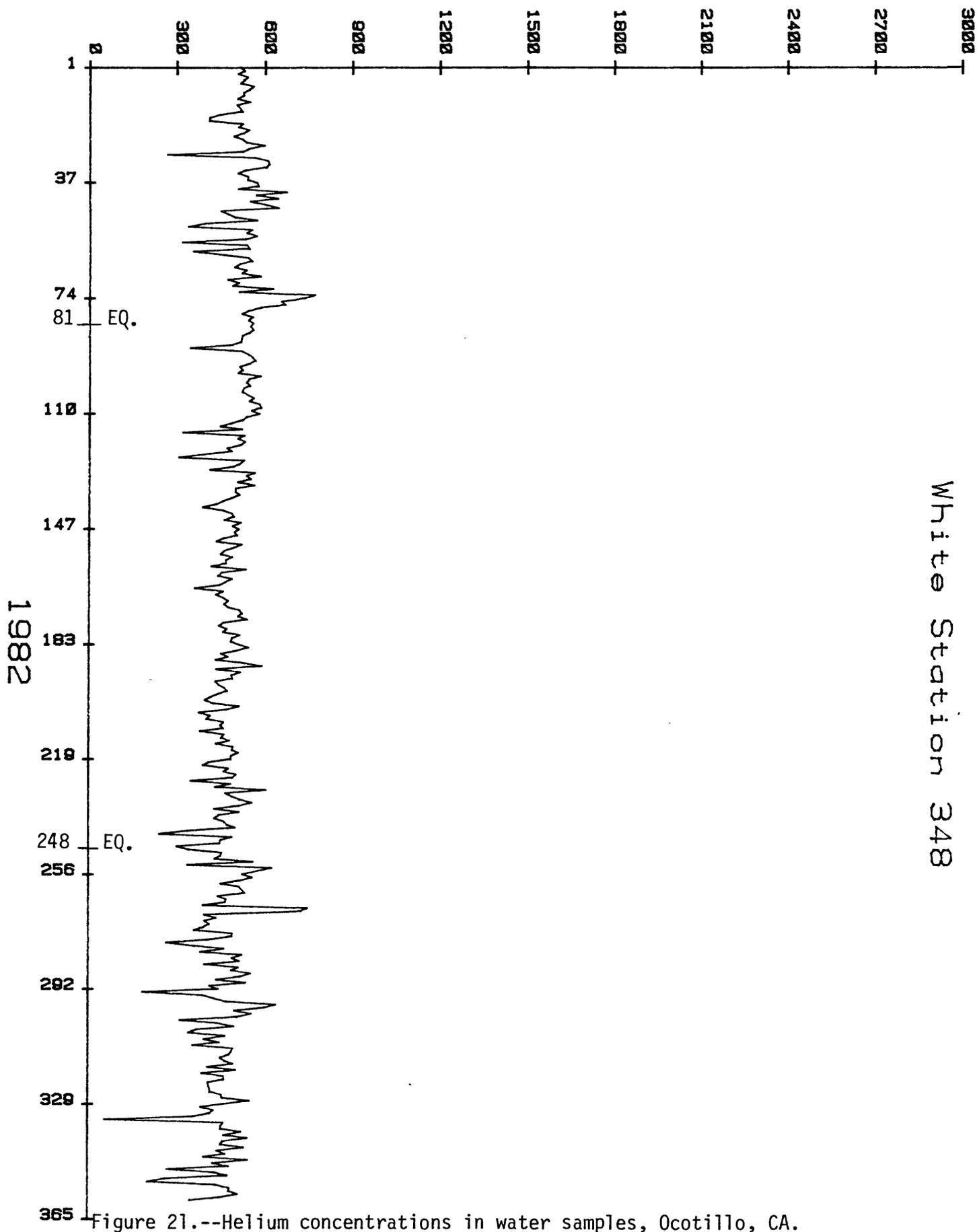
# HELIUM IN PPB/ML



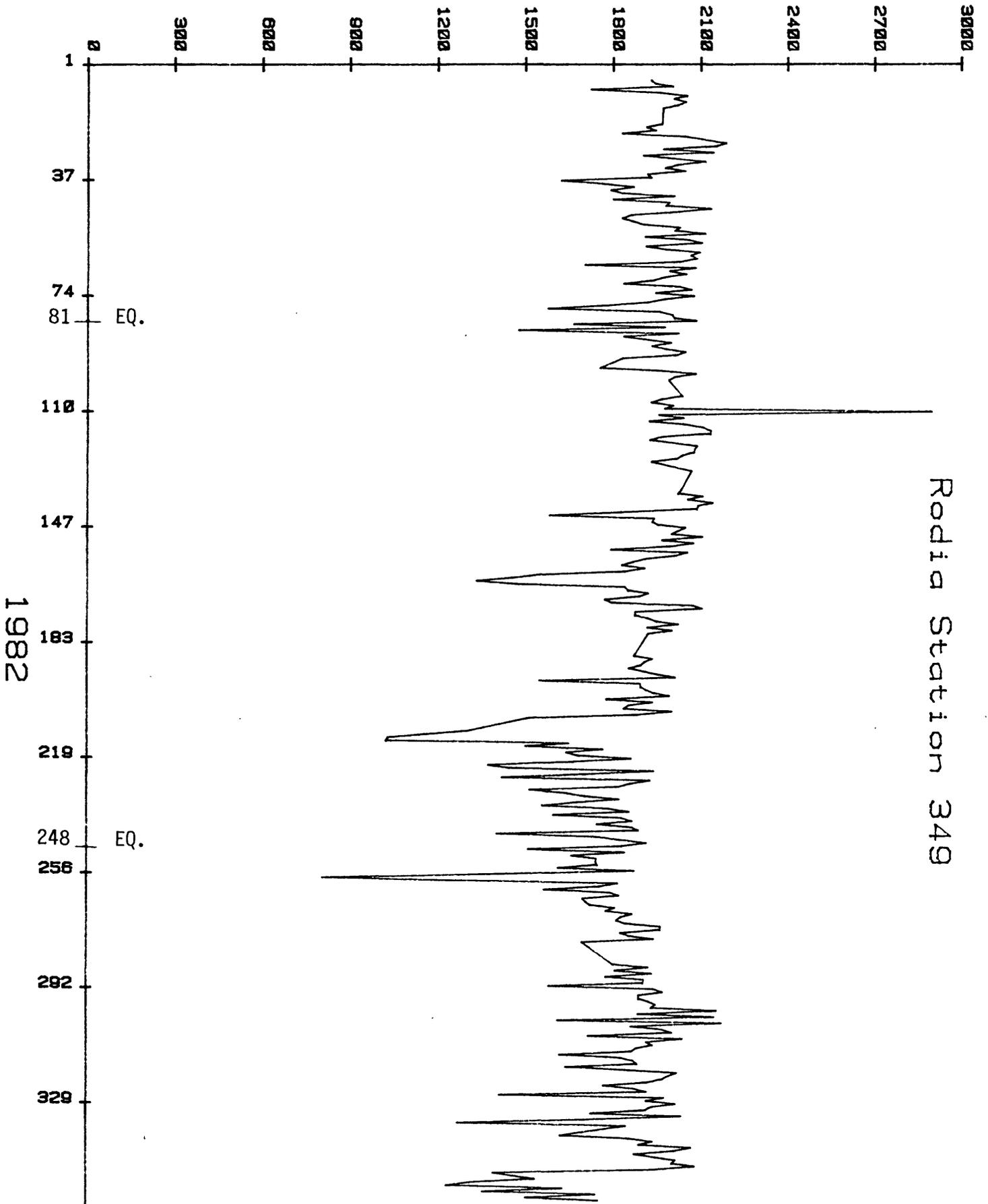
Jeska Station 347

Figure 20.--Helium concentrations in water samples, Brawley, CA.

# HELIUM IN PPB/ML



# HELIUM IN PPB/ML



Rodia Station 349

Figure 22.--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 23.--Chart showing correlation of Julian and Gregorian calendar.