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# VARIATIONS OF STREAM AND GROUND WATER URANIUM CONCENTRATIONS WITH RAINFALL IN THE NORTH CAROLINA PIEDMONT

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## ABSTRACT

Uranium contents of stream and ground water samples from the North Carolina Piedmont vary systematically with rainfall. Data for three well-stream pairs sampled at three-week intervals for one year show that uranium content of streams and ground waters correlates with the amount of local precipitation. The phenomenon is believed to be caused by oxidizing rainfall flushing uranium from the vadose zone.

## DISCUSSION

One factor that can influence interpretation of chemical concentrations in natural samples is seasonal variation. Such variations are to be expected as a result of weather and biological cycling, and their magnitude must be assessed.

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SRL has recently completed sampling several wells and nearby streams in the Charlotte, North Carolina, 1° x 2° NTMS quadrangle (Heffner and Ferguson, 1978) at three-week intervals for a year.

Sampling sites of each well-stream pair were one to three miles apart and were within the same drainage basin; each pair represented a different drainage basin. Most sites were previously sampled as part of an SRL orientation study in the Kings Mountain Area (Price and others, 1976).

Uranium concentration data for two well/stream pairs are summarized in Figures 1 and 2. Trends with time are quite similar for all four sites, suggesting a common cause for the observed variations in the concentration. The stream in Figure 1 normally contains a higher uranium content than the associated well. In Figure 3, alkalinity and uranium content time trends show a striking resemblance to rainfall trends.

Figure 4 shows rainfall data (NOAA) for 6-, 4-, 3-, and 1-week periods prior to sample collection dates. These data are from Douglas Municipal Airport, about 25 miles (40 km) from the sampling sites. The correspondence between the shapes of the rainfall curves and those for uranium content variation strongly suggests that rainfall is the common causal factor influencing concentration changes. Each influx of oxidizing rainwater may flush uranium from the vadose zone, thus increasing concentrations in well and stream waters.

Field and analytical data from this study are presented in Tables 1 through 6.

Because of the large concentration variations observed, choice of an *a priori* anomaly threshold is not practical. Examination of the data for a given area, however, will allow assignment of conditional thresholds. For example, Well Site 106 did not drop below 17 ppb U; whereas Well Site 107 contains less than 0.1 ppb U 30% of the time, and more than 0.5 ppb U about 12% of the time. Thus, an anomaly threshold at about 0.5 ppb U would allow reliable discrimination between these two sites.

Similar variations of uranium concentrations in ground water have been discussed by Grimbert (1963) and Rose (1976).

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*These reports are available on microfiche from the Grand Junction Office, DOE, for $6.00. Prepaid orders should be sent to: Bendix Field Engineering Corporation, Technical Library, P. O. Box 1569, Grand Junction, Colorado 81501. Checks or money orders should be made out to Bendix Field Engineering Corporation, the operating contractor for DOE's Grand Junction Office.

TABLE 1

**Data for Stream Site NCCL 006**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/18/77 | 7.1 | 41 | 0.28 | 11 | 0.069 |
| 3/11/77 | 7.3 | 50 | 0.24 | 13 | 2.157 |
| 4/1/77 | 6.7 | 52 | 0.22 | 19 | 1.283 |
| 4/21/77 | 7.0 | 59 | 0.24 | 20 | 1.636 |
| 5/14/77 | 6.7 | 61 | 0.38 | 23 | 0.135 |
| 6/2/77 | 6.5 | 51 | 0.34 | 22 | 0.199 |
| 6/24/77 | 6.7 | 57 | 0.40 | 28 | 0.673 |
| 7/15/77 | 7.2 | 72 | 0.44 | 30 | 0.079 |
| 8/7/77 | 7.5 | 62 | 0.38 | 28 | 0.018 |
| 8/25/77 | 7.6 | 70 | 0.36 | 25 | 0.303 |
| 9/17/77 | 7.2 | 88 | 0.38 | 26 | 0.492 |
| 10/9/77 | 7.1 | 70 | 0.32 | 19 | 0.432 |
| 10/29/77 | 7.4 | 70 | 0.34 | 18 | 0.332 |
| 11/22/77 | 7.6 | 55 | 0.34 | 14 | 0.313 |
| 12/20/77 | 6.7 | 48 | 0.34 | 4 | 0.266 |
| 12/31/77 | 7.1 | 42 | 0.32 | 8 | 0.153 |
| 1/21/78 | 4.3 | 50 | 0.20 | 6 | 0.067 |

TABLE 2

**Data for Well Site NCCL 106**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/18/77 | 7.2 | 88 | 0.76 | 11 | 136.7 |
| 3/11/77 | 6.8 | 100 | 0.62 | 13 | 157.4 |
| 4/1/77 | 6.9 | 100 | 0.66 | 17 | 127.2 |
| 4/21/77 | 5.9 | 53 | 0.32 | 19 | 27.14 |
| 5/14/77 | 6.3 | 62 | 0.28 | 22 | 33.0 |
| 6/2/77 | 6.0 | 48 | 0.26 | 22 | 23.0 |
| 6/24/77 | 7.5 | 78 | 0.46 | 28 | 42.1 |
| 7/15/77 | 7.4 | 65 | 0.26 | 30 | 17.1 |
| 8/7/77 | 7.7 | 90 | 0.38 | 28 | 49.07 |
| 8/27/77 | 7.8 | 130 | 0.36 | 25 | 149.4 |
| 9/17/77 | 7.4 | 124 | 0.84 | 22 | 146 |
| 10/9/77 | 7.8 | 124 | 0.52 | 19 | 148 |
| 10/29/77 | 7.6 | 121 | 1.06 | 17 | 162 |
| 11/22/77 | 7.6 | 115 | 0.90 | 14 | 142 |
| 12/10/77 | 7.0 | 90 | 0.94 | 4 | 150 |
| 12/31/77 | 7.2 | 90 | 0.92 | 12 | 151 |
| 1/21/78 | 4.7 | 98 | 0.74 | 6 | 124 |

TABLE 3

**Data for Stream Site NCCL 007**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/19/77 | 7.5 | 41 | 0.26 | 8 | 1.565 |
| 3/11/77 | 7.0 | 43 | 0.20 | 13 | 0.110 |
| 4/17/77 | 6.6 | 47 | 0.18 | 19 | 0.189 |
| 4/21/77 | 6.7 | 50 | 0.22 | 21 | 0.107 |
| 5/14/77 | 7.0 | 58 | 0.32 | 24 | 0.097 |
| 6/2/77 | 7.2 | 65 | 0.32 | 22 | 0.235 |
| 6/24/77 | 7.4 | 68 | 0.32 | 29 | 0.235 |
| 7/15/77 | 7.4 | 53 | 0.32 | 27 | 0.627 |
| 8/7/77 | 8.2 | 102 | 0.34 | 30 | 0.040 |
| 8/25/77 | 8.1 | 91 | 0.38 | 26 | 0.552 |
| 9/17/77 | 7.3 | 72 | 0.24 | 23 | 0.533 |
| 10/9/77 | 8.3 | 70 | 0.24 | 21 | 0.626 |
| 10/29/77 | 7.5 | 61 | 0.26 | 19 | 0.386 |
| 11/22/77 | 7.6 | 55 | 0.34 | 15 | 0.382 |
| 12/10/77 | 6.3 | 48 | 0.30 | 7 | 0.214 |
| 12/31/77 | 7.0 | 38 | 0.30 | 7 | 0.185 |
| 1/21/78 | 4.9 | 41 | 0.18 | 6 | 0.074 |

TABLE 4

**Data for Well Site NCCL 107**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/19/77 | 5.8 | 121 | 0.10 | 17 | 0.250 |
| 3/11/77 | 5.4 | 110 | 0.08 | 15 | 0.168 |
| 4/1/77 | 4.8 | 110 | 0.04 | 16 | 0.211 |
| 4/21/77 | 5.1 | 110 | 0.08 | 17 | 0.119 |
| 5/14/77 | 6.4 | 110 | 0.18 | 21 | 0.147 |
| 6/2/77 | 5.7 | 92 | 0.12 | 19 | 0.099 |
| 6/24/77 | 7.1 | 62 | 0.10 | 27 | 0.513 |
| 7/15/77 | 7.6 | 85 | 0.12 | 21 | 0.534 |
| 8/7/77 | 7.4 | 72 | 0.14 | 21 | 0.003 |
| 8/25/77 | 5.7 | 74 | 0.08 | 19 | 0.041 |
| 9/17/77 | 5.5 | 68 | 0.16 | 20 | 0.298 |
| 10/9/77 | 5.6 | 67 | 0.10 | 17 | 0.094 |
| 10/29/77 | 5.8 | 63 | 0.14 | 16 | 0.155 |
| 11/22/77 | 5.9 | 68 | 0.14 | 15 | 0.126 |
| 12/10/77 | 5.9 | 55 | 0.14 | 10 | 0.053 |
| 12/31/77 | 6.1 | 55 | 0.20 | 12 | 0.074 |
| 1/21/78 | 4.0 | 148 | 0.06 | 12 | 0.100 |

TABLE 5

**Data for Stream Site NCCL 008**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/19/77 | 7.2 | 30 | 0.16 | 10 | 0.073 |
| 3/11/77 | 7.2 | 30 | 0.16 | 13 | 0.066 |
| 4/17/77 | 6.3 | 32 | 0.14 | 18 | 0.189 |
| 4/21/77 | 6.7 | 38 | 0.16 | 20 | 0.132 |
| 5/14/77 | 7.3 | 41 | 0.14 | 22 | 0.097 |
| 6/2/77 | 8.0 | 44 | 0.20 | 20 | 0.163 |
| 6/24/77 | 7.1 | 40 | 0.26 | 29 | 0.187 |
| 7/15/77 | 7.7 | 42 | 0.24 | 27 | 0.404 |
| 8/7/77 | 7.3 | 45 | 0.24 | 31 | 0.064 |
| 8/25/77 | 7.7 | 80 | 0.22 | 25 | 0.432 |
| 9/17/77 | 7.2 | 32 | 0.14 | 24 | 0.429 |
| 10/9/77 | 7.8 | 40 | 0.20 | 20 | 0.377 |
| 10/29/77 | 7.6 | 42 | 0.20 | 18 | 0.453 |
| 11/21/77 | 7.9 | 35 | 0.18 | 13 | 0.625 |
| 12/10/77 | 6.0 | 30 | 0.18 | 7 | 0.809 |
| 12/31/77 | 6.8 | 38 | 0.20 | 8 | 0.206 |
| 1/21/78 | 4.8 | 32 | 0.10 | 7 | 0.074 |

TABLE 6

**Data for Well Site NCCL 418**

| Date | pH | Cond., $\Omega^{-6}cm^{-1}$ | Alk., meq/L | Temp., °C | U, ppb |
|---|---|---|---|---|---|
| 2/19/77 | 6.4 | 99 | 0.26 | 15 | 0.282 |
| 3/11/77 | 5.9 | 99 | 0.22 | 15 | 0.414 |
| 4/1/77 | 6.0 | 110 | 0.22 | 17 | 0.346 |
| 4/21/77 | 5.9 | 120 | 0.30 | 19 | 0.380 |
| 5/14/77 | 6.3 | 104 | 0.28 | 23 | 0.460 |
| 6/2/77 | 7.2 | 100 | 0.24 | 19 | 0.573 |
| 6/24/77 | 7.3 | 103 | 0.20 | 22 | 0.543 |
| 7/15/77 | 7.9 | 98 | 0.12 | 23 | 0.725 |
| 8/7/77 | 7.8 | 104 | 0.20 | 28 | 0.179 |
| 8/25/77 | 6.1 | 105 | 0.14 | 23 | 0.623 |
| 10/9/77 | 6.6 | 92 | 0.24 | 20 | 0.389 |
| 10/29/77 | 6.6 | 92 | 0.28 | 18 | 0.519 |
| 11/21/77 | 6.9 | 90 | 0.22 | 23 | 0.716 |
| 12/31/77 | 5.7 | 78 | 0.24 | 10 | 0.477 |
| 1/21/78 | 5.5 | 92 | 0.38 | 9 | 0.179 |

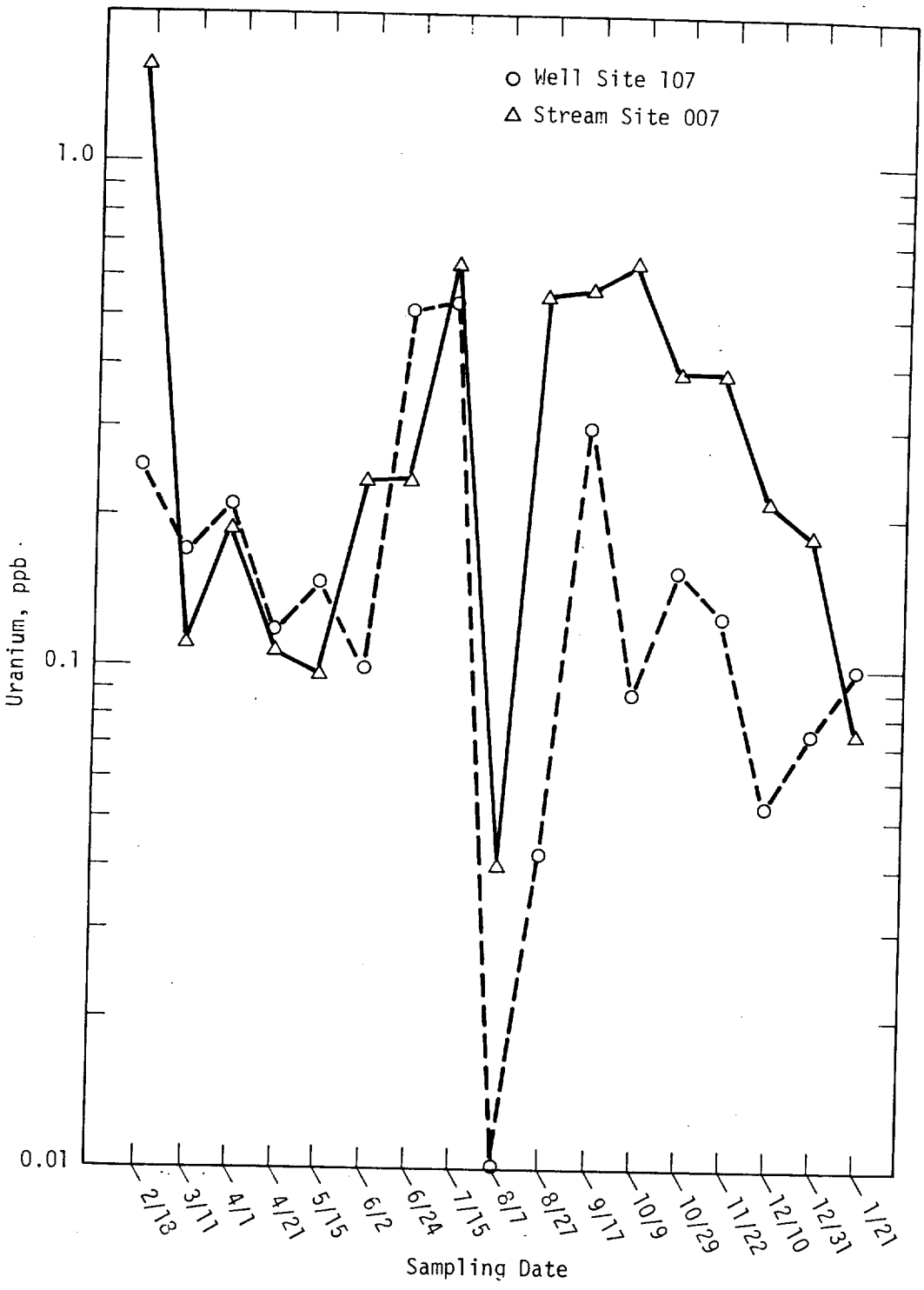


FIGURE 1. Variation of uranium content with time at a well-stream pair (Sites NCCL 107 and 007).

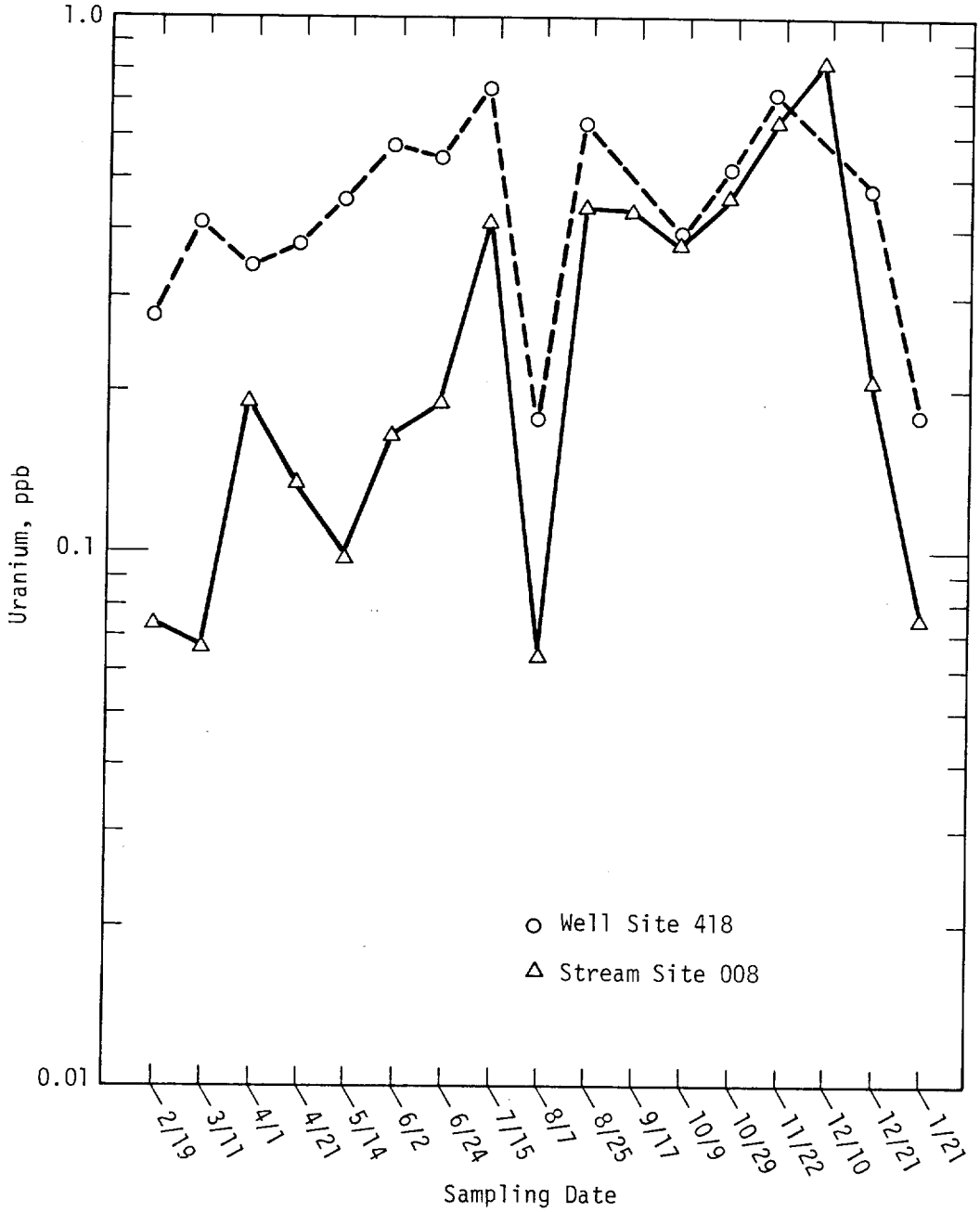


FIGURE 2. Variation of uranium content with time at a well-stream pair (Sites NCCL 418 and 008).

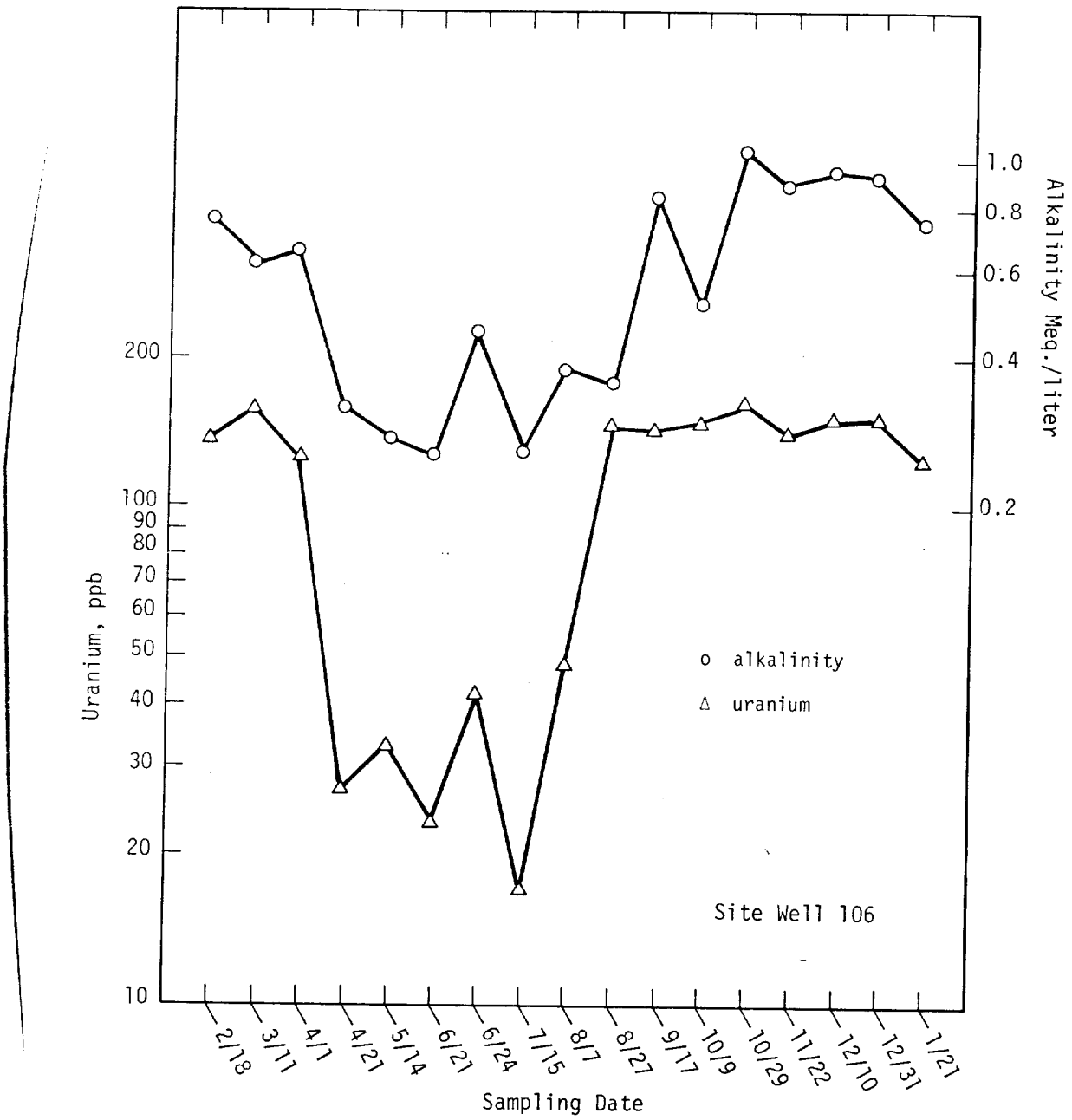


FIGURE 3. Variation of uranium and alkalinity with time at a well (Site NCCL 006).

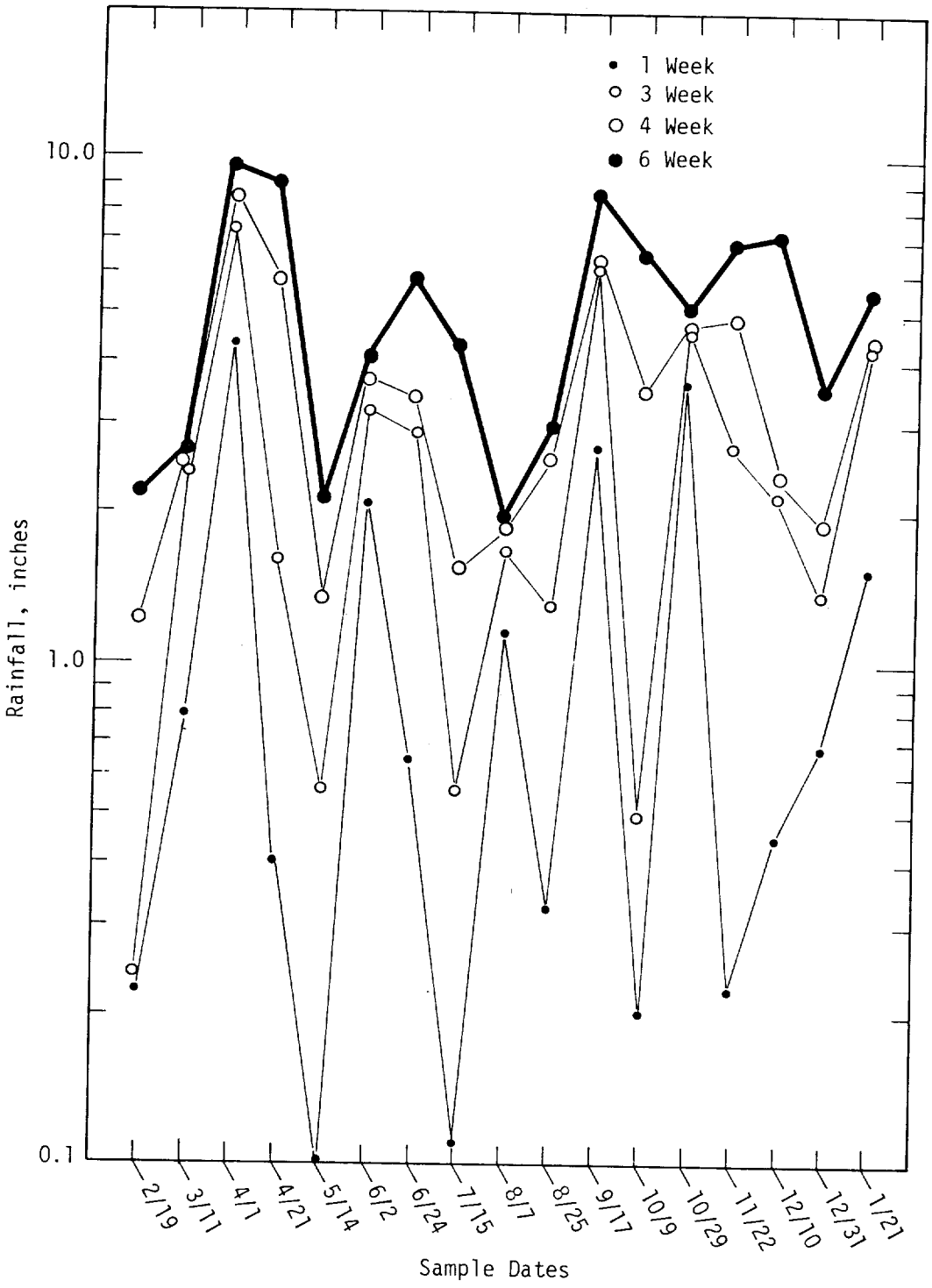


FIGURE 4. Rainfall data for 6-, 4-, 3-, and 1- week periods prior to sampling dates.