

TECHNICAL REPORT 93-2

**SEISMIC ACTIVITY NEAR THE
V.C. SUMMER NUCLEAR STATION**

FOR THE PERIOD

APRIL - JUNE, 1993

BY

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COLUMBIA, SOUTH CAROLINA 29208**

CONTRACT NO. N622702

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INTRODUCTION

Analysis of the seismic activity near the V.C. Summer Nuclear Station in South Carolina between April 1 and June 30, 1993 is presented in this report. During this period, four events were recorded in the vicinity of the Monticello Reservoir and all were located. All four events were located on the north, northwest border of the lake. $M_L = 0.8$ was the largest magnitude recorded.

SEISMIC NETWORK

Earthquakes during this period were recorded on stations of Monticello Reservoir and South Carolina Seismic Networks. The configuration of stations utilized to locate Monticello Reservoir events is shown in Figure 1 and station coordinates are listed in Appendix I. The operational status of the network is given in Appendix II.

DATA ANALYSIS

Hypocentral locations have been determined using the computer program HYPO71 (Lee and Lahr, 1972). The velocity model used in the earthquake locations is given in Appendix III. The format of the HYPO71 output is given in Appendix IV. The event magnitude was determined from the signal duration at JSC using the following relation:

$$M_L = -1.83 + 2.04 \log D,$$

where D is the signal duration (seconds).

An estimate of daily energy release was determined using a simplified magnitude (M_L) - energy (E) relation by Gutenberg and Richter (1956):

$$\log_{10} E = 11.8 + 1.5 M_L$$

OBSERVED SEISMICITY DURING APRIL - JUNE, 1993

Seismicity around Monticello Reservoir was low during the second quarter of 1993. Four events were recorded and located north, northwest of the lake (Figure 2). Two events occurred in April, one occurred in May and one occurred in June. The locations were rated good to poor quality (B-D; Appendix V). The largest event with magnitude of $M_L = 0.8$ occurred on May 24 at 16:22:57.02 UTC. Of the remaining three, two had magnitudes of $M_L = 0.0$ and one had a magnitude of $M_L = 0.2$. The long term decline in seismicity observed at Monticello Reservoir is continuing (Figure 3). The cumulative seismicity at Monticello Reservoir has shown relative flattening since 1985-86 (Figure 4).

CORRELATION OF WATER LEVEL WITH SEISMICITY

Monticello Reservoir is a pumped storage facility. Any decrease in the reservoir level associated with power generation is recovered when water is pumped back into the reservoir. There can be normal variations up to five feet per day between maximum and minimum water levels. The water level has been monitored to see if there is any correlation between the daily or seasonal changes in the reservoir level and the local seismicity. Water levels are compared with seismicity in Figure 5. The top panel shows the average water level; the error bars show the maximum and minimum water levels each day. The second panel shows the change in water level from day to day. The number of events per day and the log of energy released are shown in the lower histograms. These charts include all reported earthquakes listed in Appendix V. The average water level, daily changes in water level, number of earthquakes and energy release are given in Appendix VI. No systematic correlation was observed between the seismicity and reservoir level fluctuations.

CONCLUSIONS

Seismicity during the second quarter of 1993 was low ($0 \leq M_L \leq .8$), yet it occurred sporadically throughout the quarter. The earthquakes occurred on the north, northwestern bank of the reservoir within approximately 5 kilometers of each other. No systematic correlation was observed between the reservoir level fluctuations and the seismicity.

REFERENCES

- Gutenberg, B. and Richter, C.F. (1956). Magnitude and energy of earthquakes, *Ann. Geof.* 9, 1-15.
- Lee, W.H.K. and Lahr, J.C. (1972). A computer program for determining hypocenter, magnitude and first motion pattern of local earthquakes, revisions of HYPO71, U.S. Geological Survey, Open-File Report, 100 pp.

Monticello Reservoir Seismic Network

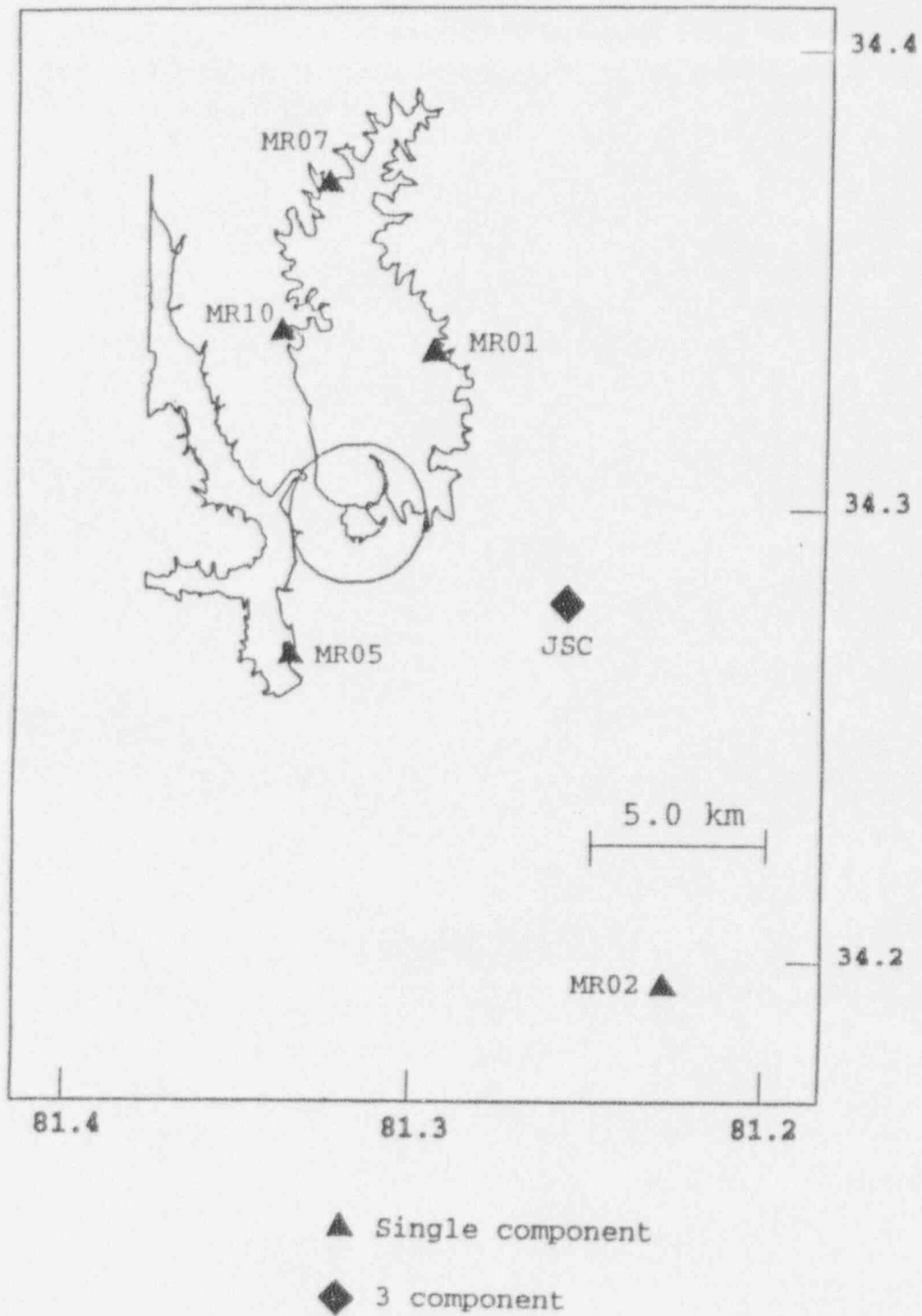


Figure 1. Location of Monticello Reservoir area showing seismic stations used in locating seismicity.

Monticello Reservoir Seismic Network

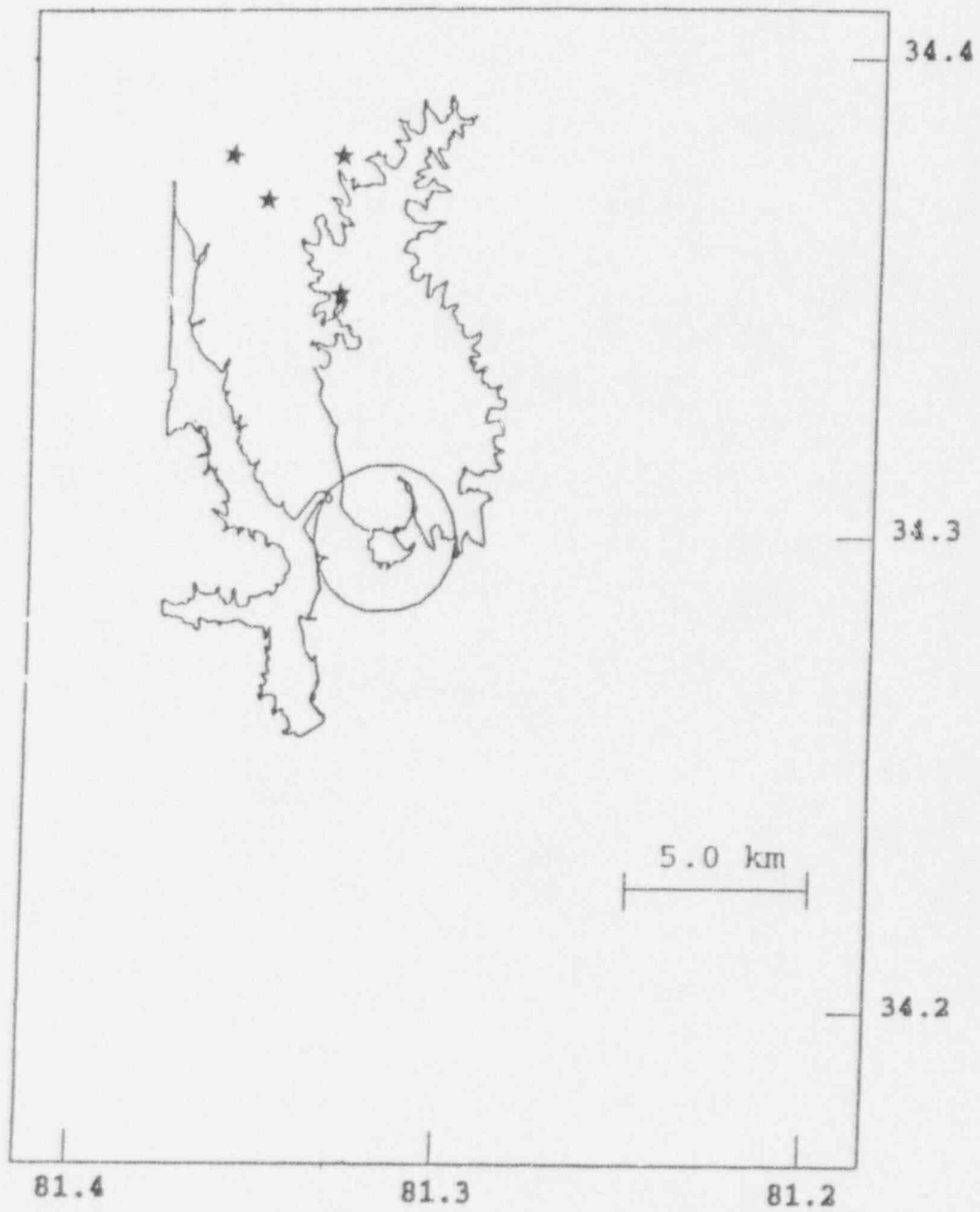


Figure 2. Events located near Monticello Reservoir during the period April - June, 1993 (stars).

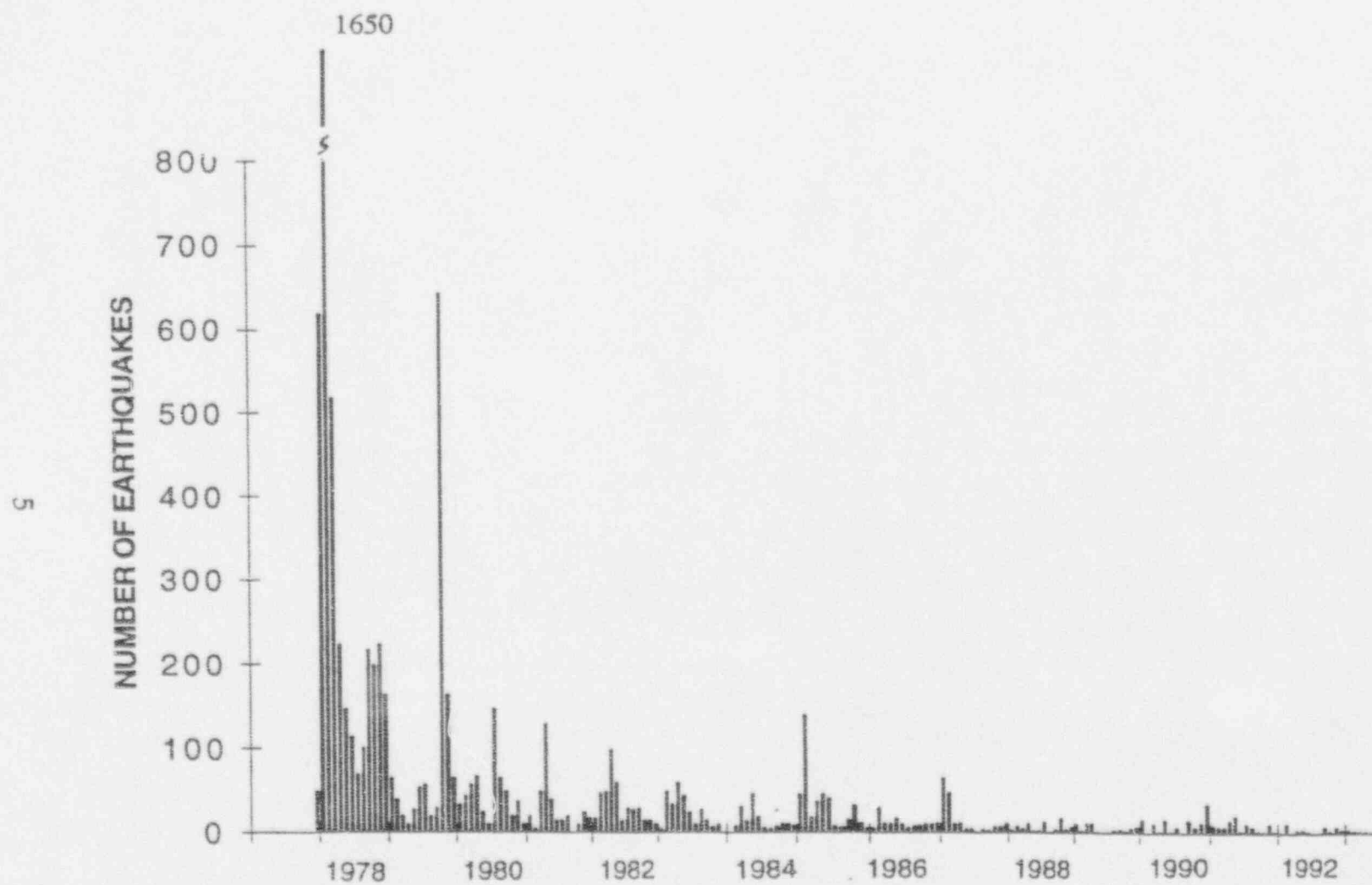


Figure 3. Earthquakes between impoundment and June, 1993.

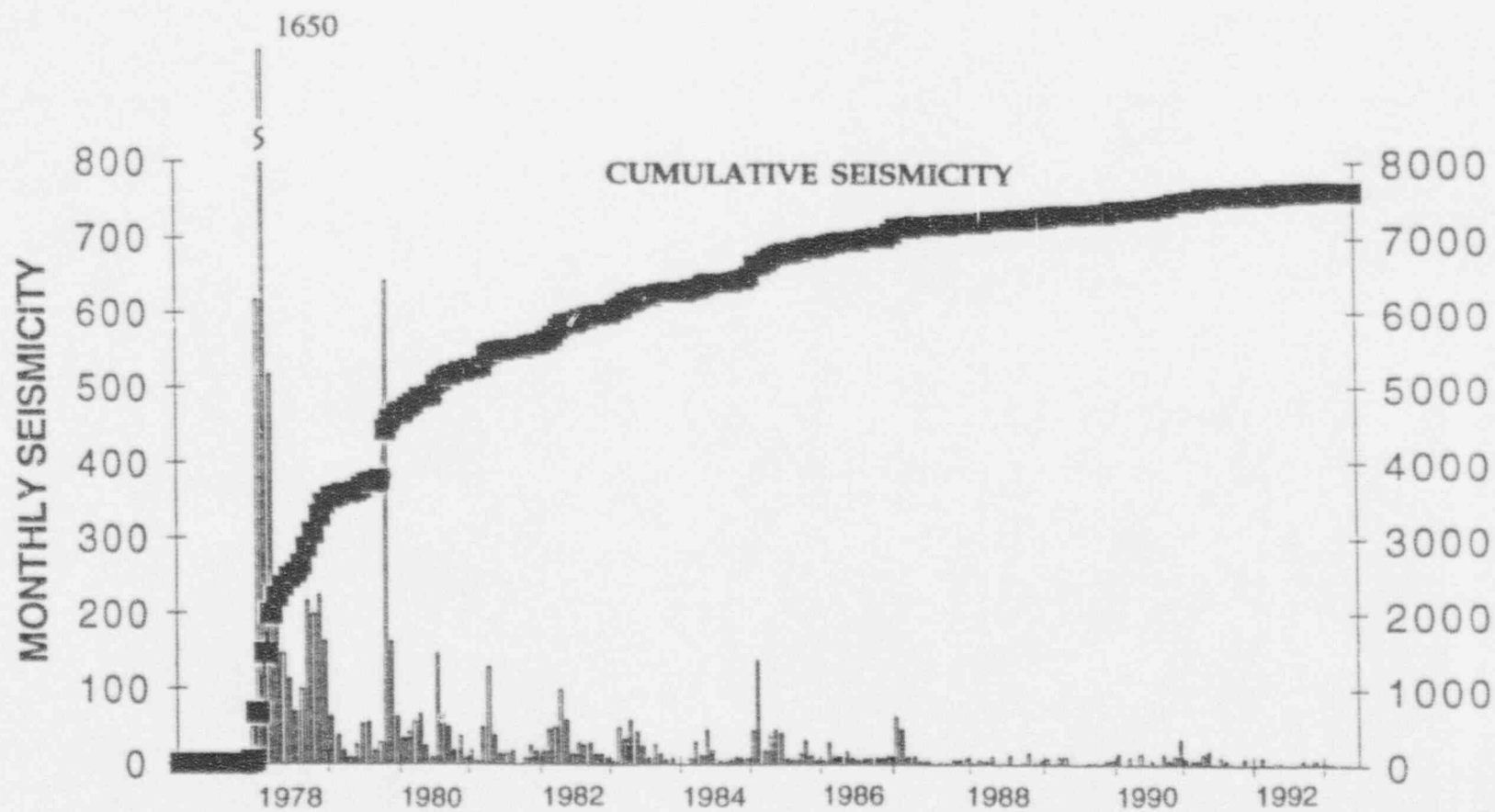


Figure 4. Monthly seismicity (bars) and cumulative seismicity (line) near Monticello Reservoir since impoundment.

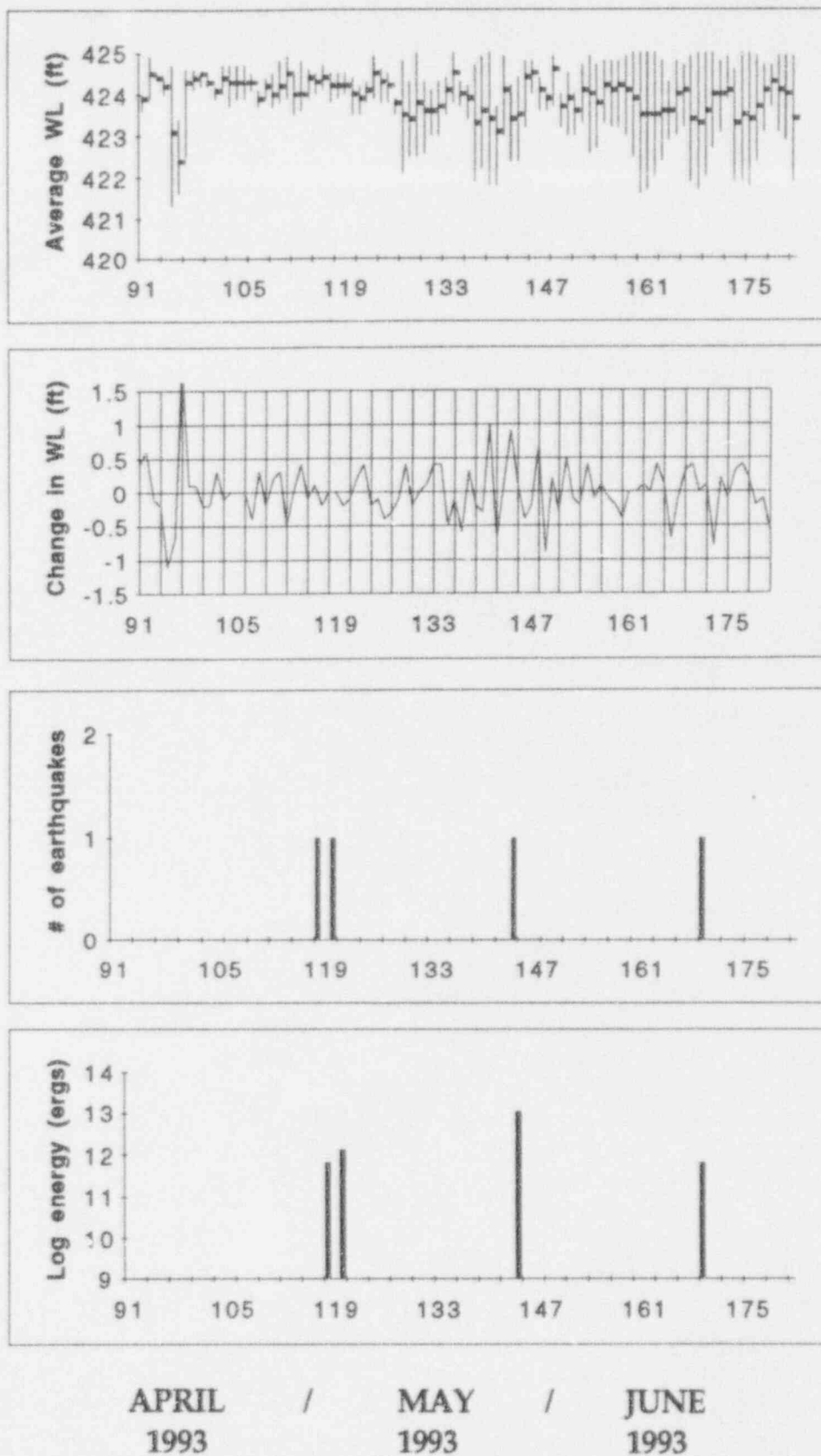


Figure 5. Comparison of daily lake level, changes in lake level, number of earthquakes and the log of energy release in ergs per day at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in water level.

APPENDIX I
STATION LOCATIONS

STATION	LAT° N	LONG °W
JSC	34°16.80'	81°15.60'
MR01	34°19.91'	81°17.74'
MR02	34°11.58'	81°13.81'
MR05	34°16.05'	81°20.05'
MR07	34°22.23'	81°19.50'
MR10	34°20.13'	81°20.25'

APPENDIX II

SEISMIC STATION OPERATIONAL STATUS

APRIL 1 - JUNE 30, 1993

STATION	PERCENT DOWNTIME
MR01	6.0
MR02	7.7
MR05	1.1
MR07	3.3
MR10	1.1
JSC	0

APPENDIX III
MONTICELLO RESERVOIR
VELOCITY MODEL

Velocity km/sec	Depth to top km
1.00	0.00
5.40	0.03
5.90	0.18
6.10	0.46
6.30	0.82
8.10	30.00

APPENDIX IV
MONTICELLO EARTHQUAKES
HYPO71 FORMAT

Column 1	Date
Column 2	Origin time (UTC) h.m.sec.
Column 3	Latitude (N) degrees, min.
Column 4	Longitude (W) degrees, min.
Column 5	Depth (km)
Column 6	Local duration magnitude.
Column 7	No. of station readings used to locate event. P and S arrivals from same stations are regarded as 2 readings.
Column 8	Largest azimuthal separation in degrees between stations.
Column 9	Epicentral distance in km to nearest station.
Column 10	Root mean square error of time residuals in sec. $RMS = R_i^2 / N_o$, where R_i is the time residual for the i th station.
Column 11	Standard error of the epicenter in km*.
Column 12	Standard error of the focal depth in km*.
Column 13	Quality of the epicentral location.

* Statistical interpretation of standard errors involves assumptions which may not be met in earthquake locations. Therefore standard errors may not represent actual error limits.

Note: If ERH or ERZ is blank, this means that it cannot be computed, because of insufficient data.

APPENDIX V
MONTICELLO RESERVOIR EARTHQUAKES
APRIL - JUNE, 1993

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
930428	558	29.53	34-23.09	81-19.60	1.00	0.01	8 322	1.6	0.16	2.6	1.8	D1
930430	1615	12.49	34-22.09	81-20.72	0.26	0.21	4 274	1.9	0.01			C1
930524	1622	57.02	34-22.87	81-21.89	0.20	0.82	5 300	3.9	0.02	3.0	1.8	D1
930618	355	10.29	34-20.98	81-19.77	0.66	0.01	7 164	1.6	0.10	1.0	1.9	B1

APPENDIX VI

Maximum and minimum water levels, change in water level, number of earthquakes and log of energy release per day at Monticello Reservoir during April 1 - June 30, 1993. Dates are given in Julian Calendar.

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
91	424	423.6	423.9	0.4	0	0
92	424.9	423.9	424.5	0.6	0	0
93	424.4	424.4	424.4	-0.1	0	0
94	424.4	424	424.2	-0.2	0	0
95	424.7	421.3	423.1	-1.1	0	0
96	423.4	421.6	422.4	-0.7	0	0
97	424.6	422.5	424.3	1.9	0	0
98	424.6	424.1	424.4	0.1	0	0
99	424.5	424.2	424.5	0.1	0	0
100	424.5	424.2	424.3	-0.2	0	0
101	424.2	423.9	424.1	-0.2	0	0
102	424.7	424	424.4	0.3	0	0
103	424.7	423.7	424.3	-0.1	0	0
104	424.7	423.9	424.3	0	0	0
105	424.7	423.9	424.3	0	0	0
106	424.5	424.1	424.3	0	0	0
107	424.1	423.7	423.9	-0.4	0	0
108	424.4	423.9	424.2	0.3	0	0
109	424.5	423.7	424	-0.2	0	0
110	424.8	423.8	424.2	0.2	0	0
111	424.9	423.9	424.5	0.3	0	0
112	424.5	423.5	424	-0.5	0	0
113	424.8	423.6	424	0	0	0
114	424.6	423.9	424.4	0.4	0	0
115	424.5	424	424.3	-0.1	0	0
116	424.7	424.1	424.4	0.1	0	0
117	424.5	423.8	424.2	-0.2	0	0
118	424.5	423.9	424.2	0	1	11.82
119	424.5	424	424.2	0	0	0
120	424.4	423.5	424	-0.2	1	12.12
121	424.2	423.5	423.9	-0.1	0	0
122	424.3	423.8	424.1	0.2	0	0
123	424.9	423.9	424.5	0.4	0	0
124	424.6	423.8	424.3	-0.2	0	0
125	424.5	423.8	424.2	-0.1	0	0
126	423.9	423.5	423.8	-0.4	0	0
127	424.8	422.1	423.5	-0.3	0	0
128	424.3	422.5	423.4	-0.1	0	0
129	425	422.5	423.8	0.4	0	0
130	424.3	422.6	423.6	-0.2	0	0
131	424.1	423	423.6	0	0	0
132	424.3	423	423.7	0.1	0	0
133	424.4	423.5	424.1	0.4	0	0

APPENDIX VI (continued)

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
134	425	423.8	424.5	0.4	0	0
135	424.3	423.7	424	-0.5	0	0
136	424.2	423.4	423.9	-0.1	0	0
137	424.7	421.9	423.3	-0.6	0	0
138	424.9	422.2	423.6	0.3	0	0
139	425	421.8	423.4	-0.2	0	0
140	423.7	421.8	423.1	-0.3	0	0
141	424.9	423	424.1	1	0	0
142	424.2	422.4	423.4	-0.7	0	0
143	424.4	422.4	423.5	0.1	0	0
144	424.8	423.2	424.4	0.9	1	13.03
145	424.8	424	424.5	0.1	0	0
146	424.4	423.6	424.1	-0.4	0	0
147	424	423.6	423.9	-0.2	0	0
148	424.9	423.7	424.6	0.7	0	0
149	424	423.2	423.7	-0.9	0	0
150	424.5	423	423.9	0.2	0	0
151	424	423	423.6	-0.3	0	0
152	424.7	423.3	424.1	0.5	0	0
153	424.9	422.6	424	-0.1	0	0
154	424.7	422.7	423.8	-0.2	0	0
155	424.8	423.3	424.2	0.4	0	0
156	424.8	423.2	424.1	-0.1	0	0
157	424.8	423.2	424.2	0.1	0	0
158	424.9	423	424.1	-0.1	0	0
159	425	422.5	423.9	-0.2	0	0
160	425	421.6	423.5	-0.4	0	0
161	425	421.7	423.5	0	0	0
162	425	422	423.5	0	0	0
163	424.8	422.4	423.6	0.1	0	0
164	424.3	422.9	423.6	0	0	0
165	424.8	423	424	0.4	0	0
166	424.7	423.2	424.1	0.1	0	0
167	424.9	421.9	423.4	-0.7	0	0
168	425	421.7	423.3	-0.1	0	0
169	425	422	423.6	0.3	1	11.82
170	425	422.7	424	0.4	0	0
171	424.8	423.1	424	0	0	0
172	424.9	423.9	424.1	0.1	0	0
173	424.6	421.9	423.3	-0.8	0	0
174	425	421.9	423.5	0.2	0	0
175	425	421.8	423.4	-0.1	0	0
176	424.9	422.4	423.7	0.3	0	0
177	424.7	423.1	424.1	0.4	0	0
178	424.7	423.7	424.3	0.2	0	0
179	424.9	423.1	424.1	-0.2	0	0
180	424.9	422.9	424	-0.1	0	0
181	424.9	421.9	423.4	-0.6	0	0