

TECHNICAL REPORT 94-2

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

FOR THE PERIOD

**APRIL-JUNE, 1994**

BY

**PRADEEP TALWANI**  
Principal Investigator

**DEPARTMENT OF GEOLOGICAL SCIENCES  
UNIVERSITY OF SOUTH CAROLINA  
COLUMBIA, SOUTH CAROLINA 29208**

**CONTRACT NO. N622702**

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PRADEEP TALWANI  
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Robert Trenkamp

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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, 1994 is presented in this report. During this period, eight events were recorded in the vicinity of the Monticello Reservoir. All eight events were located and were of relatively small magnitude.

## 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, 1994

Seismicity around Monticello Reservoir was low during the second quarter of 1994. Eight events were recorded and located (Figure 2). All events for the quarter were shallow and varied in depth between .25 and 2.2 km. The largest event occurred on April 9, 1994 at 10:12:54 UTC and had a duration magnitude of 0.8 (Appendix V). Four small events occurred on April 30, 1994 in a 36 minute period between 13:08:30 and 13:44:06 UTC (Appendix V). Three of the April 30th events occurred in a 3 minute mini burst northwest of MR01 (Figure 2). The majority of the events were located in the central area of the reservoir between Stations MR01 and MR10. The remaining events occurred on the northwest flank of the reservoir north and south of Station MR07 (Figure 2). Five of the event locations were of good quality while the remaining three event locations were of fair quality (Appendix V). The long term decline in seismicity observed at Monticello Reservoir is continuing (Figure 3) and the cumulative seismicity 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 1994 was low and occurred generally in the central section of the reservoir, with the exception of the two events on the northwest flank. 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

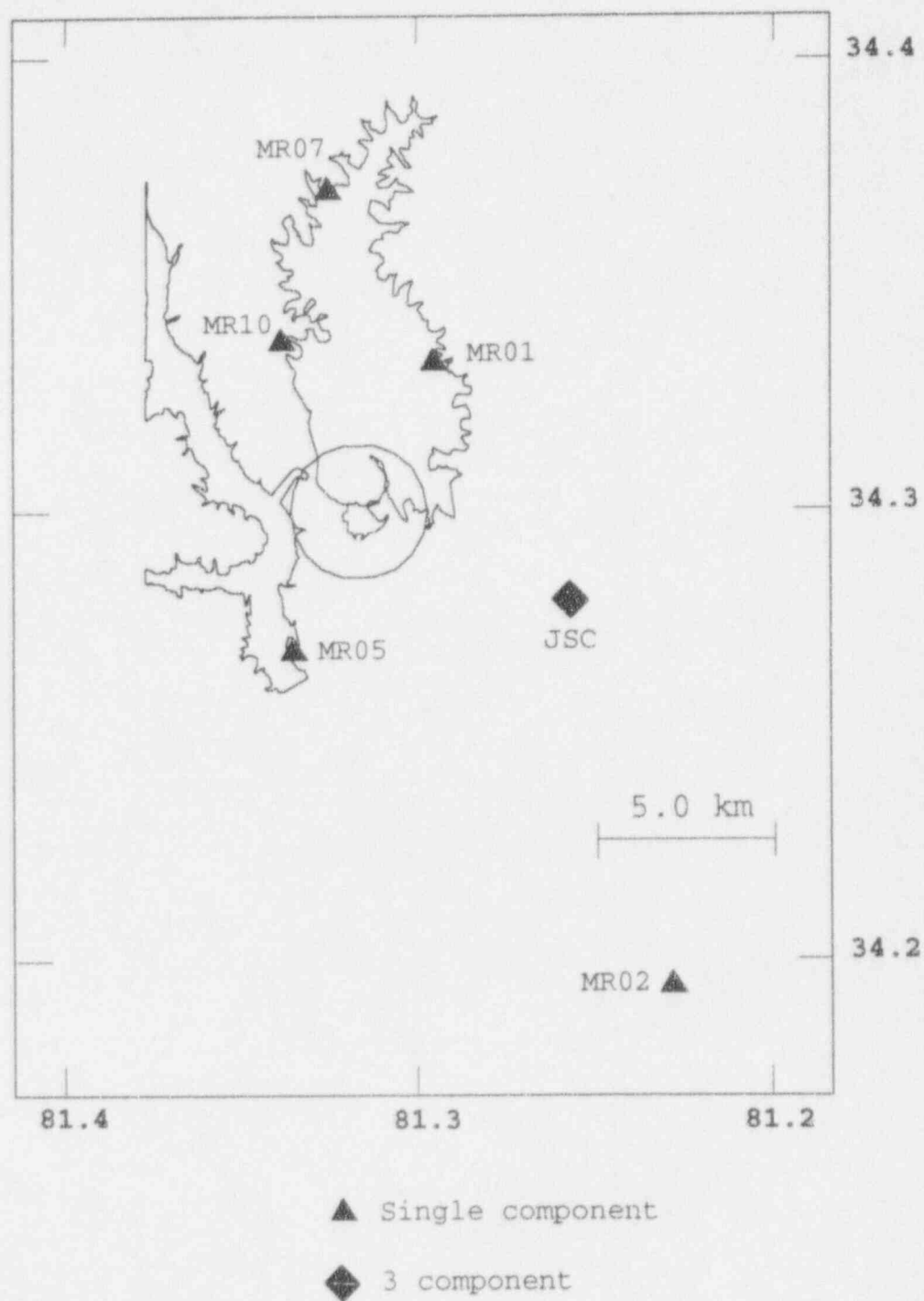


Figure 1 Location of Monticello Reservoir seismic stations.

## Monticello Reservoir Seismicity

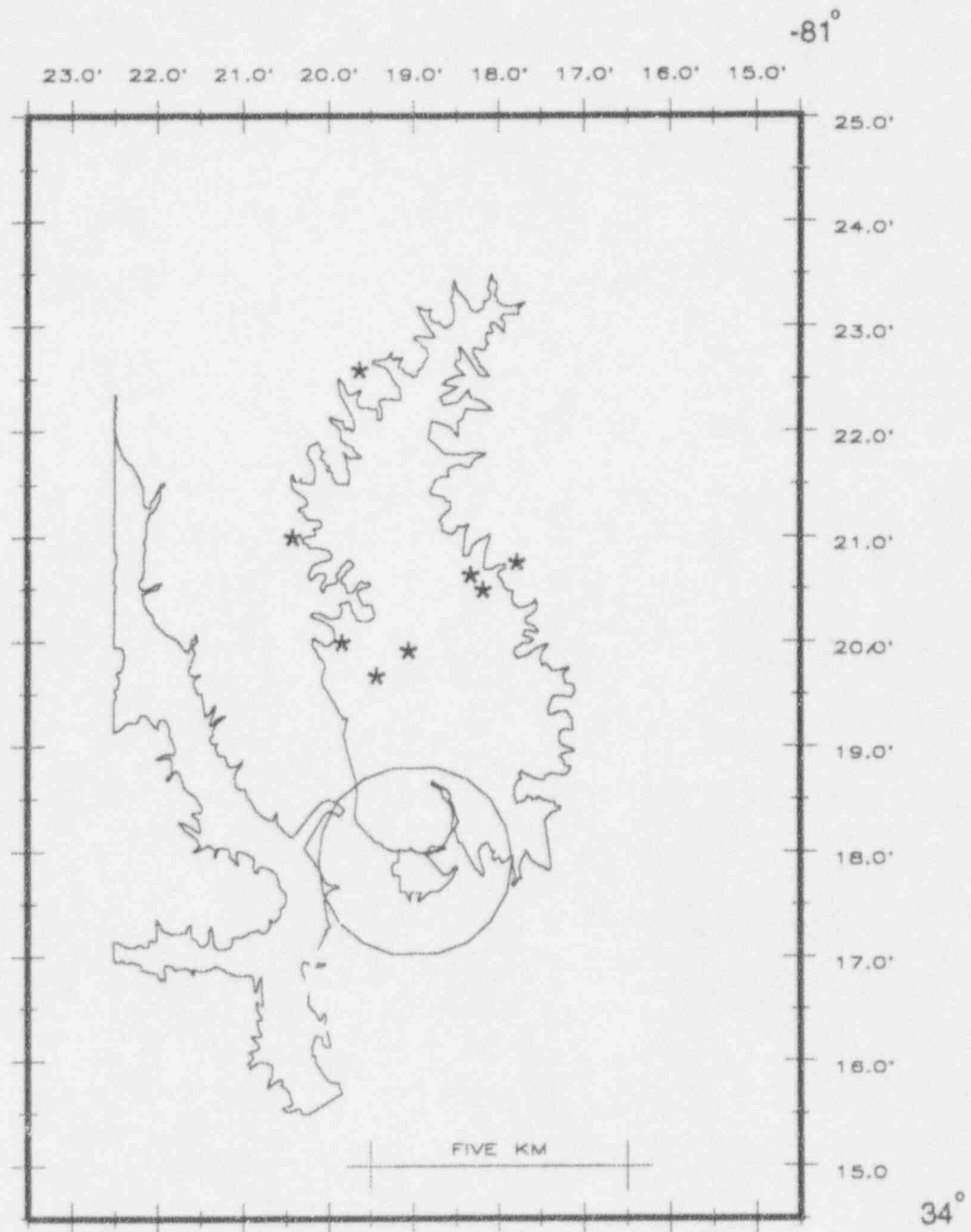


Figure 2. Events located near Monticello Reservoir during the period April - June 1994 (stars)

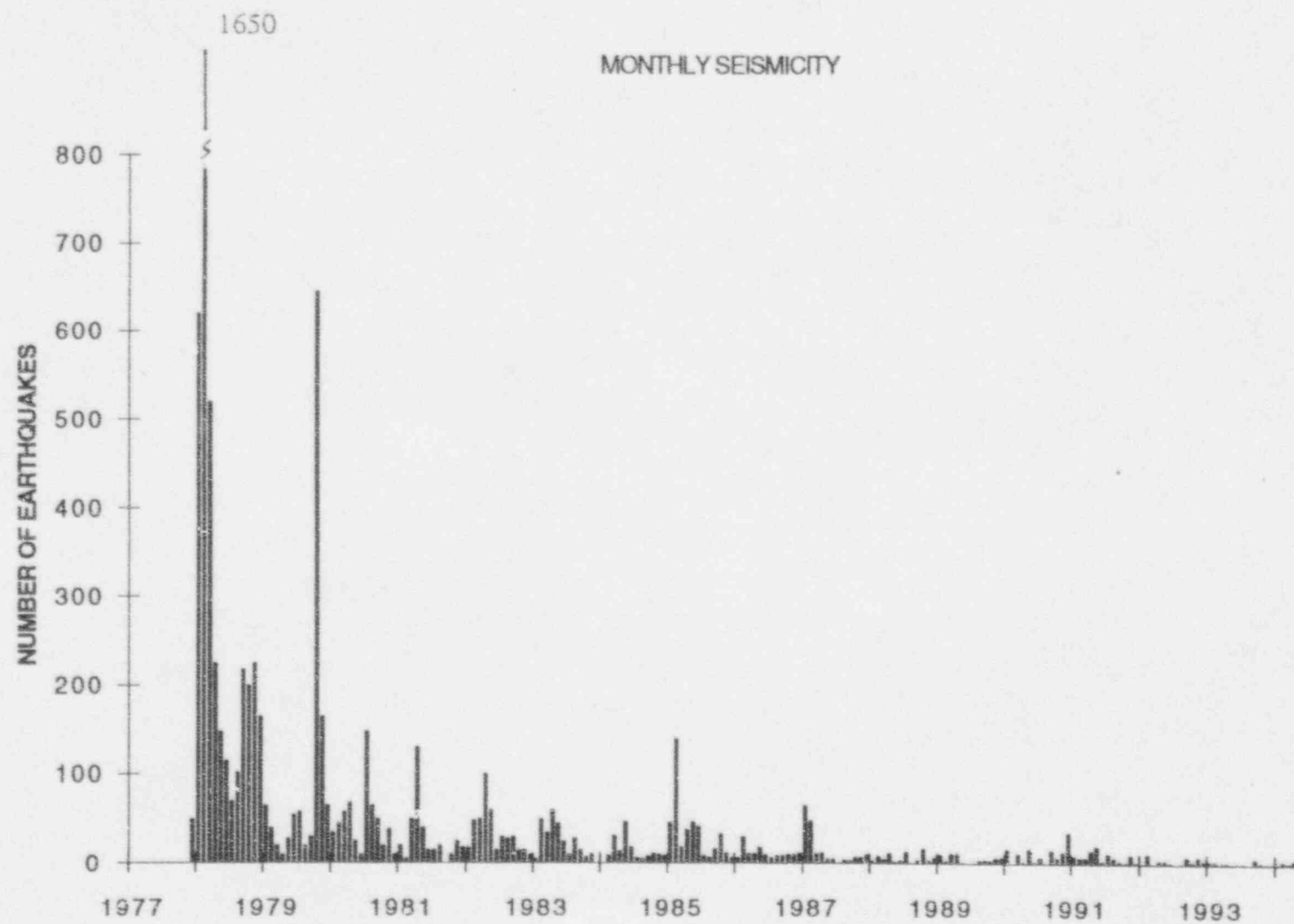


Figure 3. Earthquakes between impoundment and June, 1994.

CUMULATIVE SEISMICITY

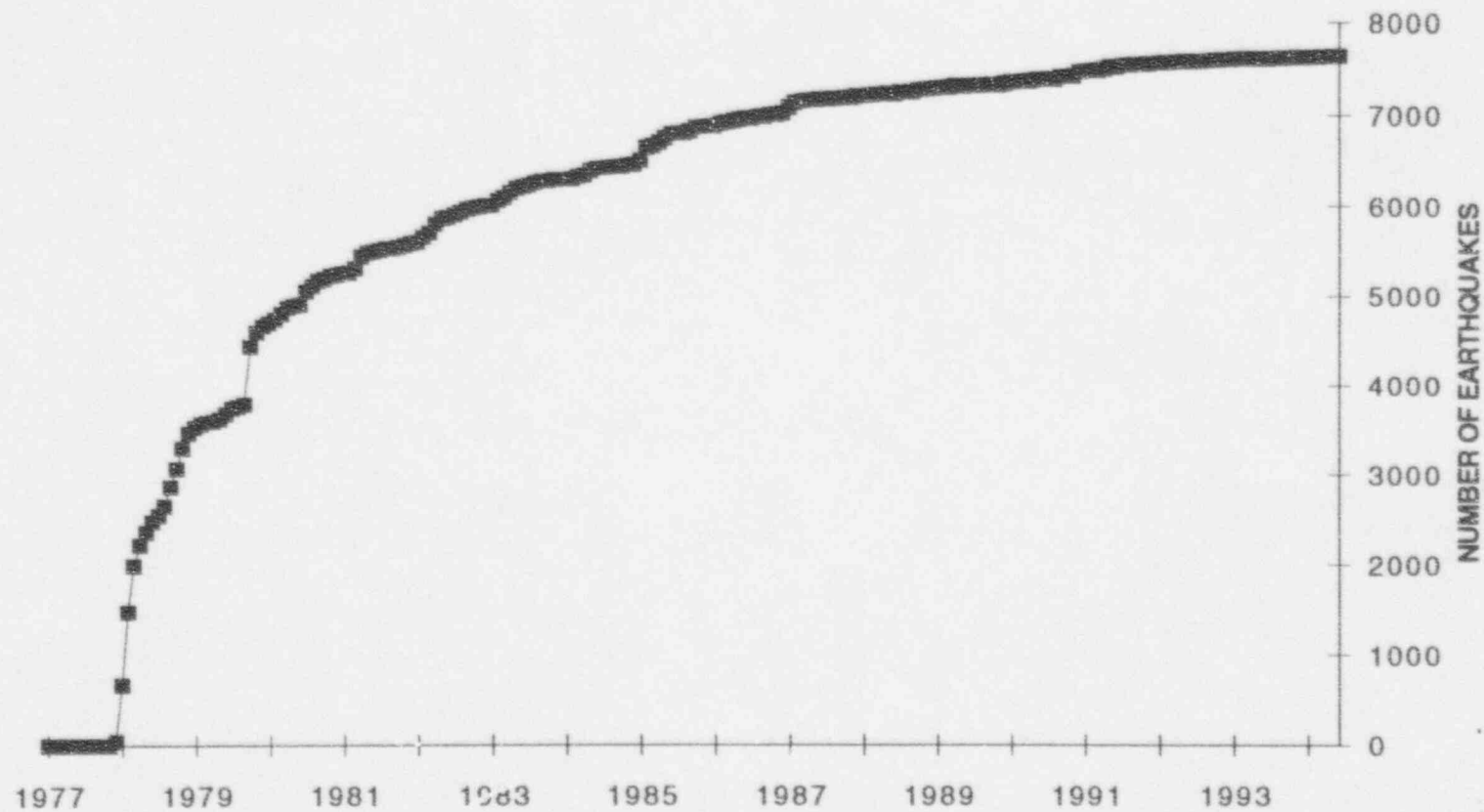
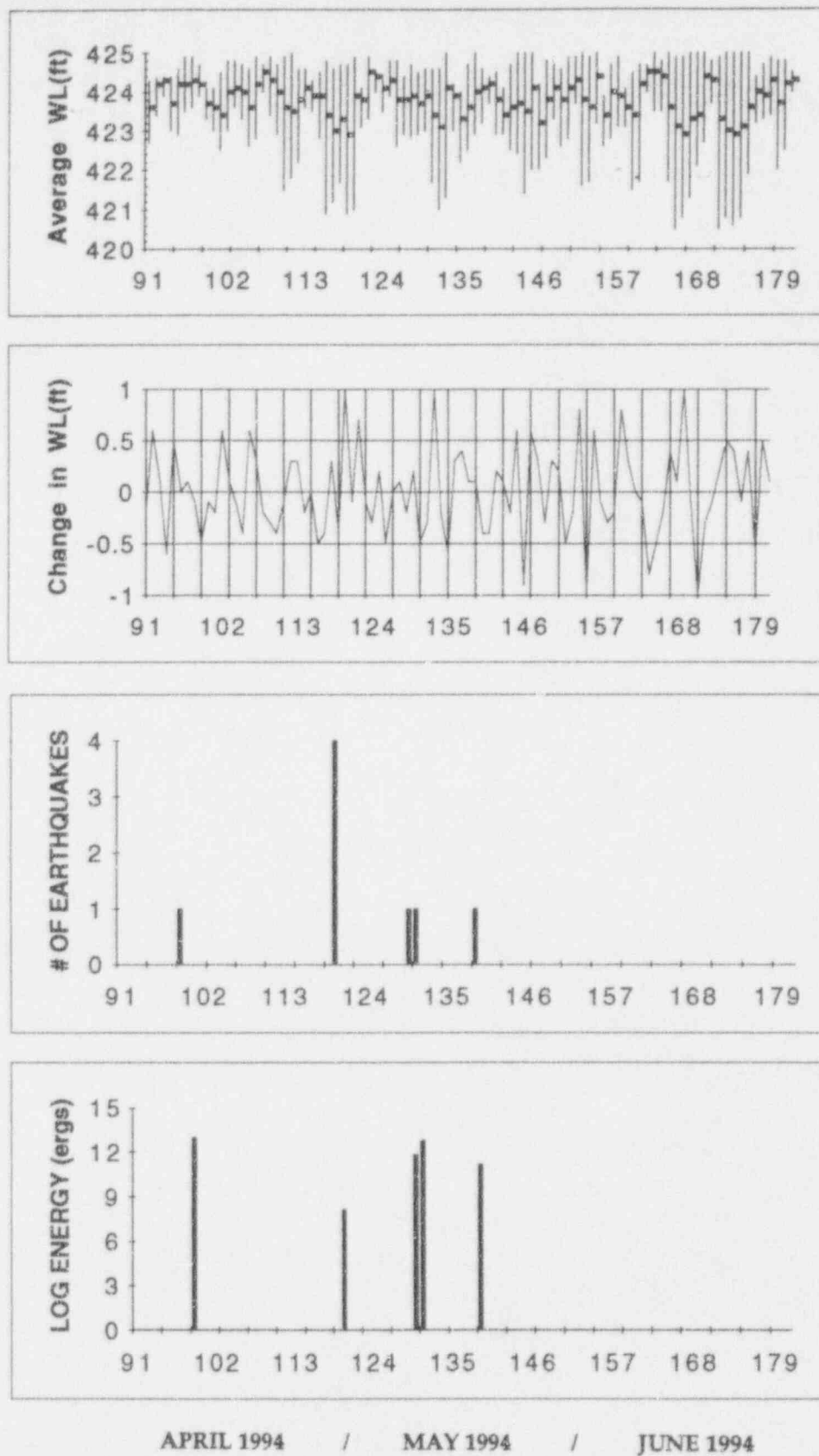


Figure 4. Cumulative seismicity near Monticello Reservoir since impoundment.





**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°20.18'	81°20.25'

APPENDIX II  
SEISMIC STATION OPERATIONAL STATUS  
APRIL 1 - JUNE 30, 1994

STATION	PERCENT DOWNTIME
MR01	1.1
MR02	1.1
MR05	3.3
MR07	1.1
MR10	1.1
JSC	1.1

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.

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\* 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, 1994

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q
940409	1012	54.96	34-19.71	81-19.48	1.48	0.78	10 119	1.5	0.04	0.2	0.4	B
940430	1341	13.83	34-20.64	81-18.37	2.17	-1.22	7 175	1.7	0.04	0.3	0.4	B
940430	1341	17.47	34-20.49	81-18.27	1.82	-0.40	10 173	1.4	0.03	0.2	0.2	B
940430	13 8	30.58	34-19.98	81-19.06	0.57	-0.40	8 103	1.9	0.10	0.5	1.5	B
940430	1344	6.70	34-20.78	81-17.84	1.81	-0.40	6 198	1.6	0.08	0.6	0.9	C
940510	1230	24.73	34-22.62	81-19.64	1.05	0.01	5 318	0.8	0.01	0.2	0.1	C
940511	513	33.97	34-20.02	81-19.93	0.25	0.68	10 119	0.6	0.06	0.3	0.9	B
940519	1011	19.15	34-20.99	81-20.43	0.81	-0.40	7 222	1.5	0.03	0.5	0.6	C

# 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, 1994. Dates are given in Julian Calendar.

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
91	424.3	422.7	423.6	-0.2	0	0
92	424.4	423.4	424.2	0.6	0	0
93	424.4	423.9	424.3	0.1	0	0
94	424.4	423	423.7	-0.6	0	0
95	424.6	422.9	424.2	0.5	0	0
96	424.9	423.5	424.2	0	0	0
97	424.9	423.6	424.3	0.1	0	0
98	424.7	423.9	424.2	-0.1	0	0
99	424.1	423.3	423.7	-0.5	1	12.97
100	424.1	423	423.6	-0.1	0	0
101	424.5	422.5	423.4	-0.2	0	0
102	424.8	423	424	0.6	0	0
103	424.8	423.6	424.1	0.1	0	0
104	424.7	423.3	424	-0.1	0	0
105	424.6	422.6	423.6	-0.4	0	0
106	424.9	422.8	424.2	0.6	0	0
107	424.7	424	424.5	0.3	0	0
108	424.9	423.4	424.3	-0.2	0	0
109	424.7	422.9	424	-0.3	0	0
110	424.9	421.5	423.6	-0.4	0	0
111	425	421.8	423.5	-0.1	0	0
112	424.6	422.2	423.8	0.3	0	0
113	424.6	423.6	424.1	0.3	0	0
114	424.3	423.5	423.9	-0.2	0	0
115	424.5	422.8	423.9	0	0	0
116	420.9	424.8	423.4	-0.5	0	0
117	424.6	421.2	423	-0.4	0	0
118	424.7	421.7	423.3	0.3	0	0
119	424.7	420.9	422.9	-0.4	0	0
120	424.9	421	423.9	1	4	8.17
121	424.1	423.1	423.8	-0.1	0	0
122	424.9	423.3	424.5	0.7	0	0
123	424.5	424	424.4	-0.1	0	0
124	424.3	423.5	424.1	-0.3	0	0
125	424.8	423.9	424.3	0.2	0	0
126	424.8	422.6	423.8	-0.5	0	0
127	424.4	422.9	423.8	0	0	0
128	424.7	422.8	423.9	0.1	0	0
129	424.5	422.9	423.7	-0.2	0	0
130	424.6	423	423.9	0.2	1	11.82
131	424.6	421.7	423.4	-0.3	1	12.82
132	424.6	421	423.1	-0.3	0	0
133	425	421.3	424.1	1	0	0

# APPENDIX VI (continued)

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
134	424.2	423	423.9	-0.2	0	0
135	424	422.2	423.3	-0.6	0	0
136	424.7	422.5	423.6	0.3	0	0
137	425	422.9	424	0.4	0	0
138	424.6	423.2	424.1	0.1	0	0
139	424.4	423.7	424.2	0.1	1	11.2
140	424.5	422.9	423.8	-0.4	0	0
141	424.1	422.9	423.4	-0.4	0	0
142	424.7	422.5	423.6	0.2	0	0
143	425	422.4	423.7	0.1	0	0
144	425	421.4	423.5	-0.2	0	0
145	425	422	424.1	0.6	0	0
146	424.2	422	423.2	-0.9	0	0
147	424.8	422.3	423.8	0.6	0	0
148	424.9	423.3	424.1	0.3	0	0
149	424.6	422.6	423.8	-0.3	0	0
150	424.9	422.8	424.1	0.3	0	0
151	424.9	423.7	424.3	0.2	0	0
152	425	421.6	423.8	-0.5	0	0
153	424.9	421.7	423.6	-0.2	0	0
154	425	423.2	424.4	0.8	0	0
155	423.9	422.6	423.4	-1	0	0
156	424.7	422.8	424	0.6	0	0
157	424.9	423.1	423.9	-0.1	0	0
158	424.1	423.1	423.6	-0.3	0	0
159	424.5	421.5	423.4	-0.2	0	0
160	424.7	421.7	424.2	0.8	0	0
161	424.7	424	424.5	0.3	0	0
162	425	423.5	424.5	0	0	0
163	424.8	423.5	424.4	-0.1	0	0
164	425	421.7	423.6	-0.8	0	0
165	424.9	420.5	423.1	-0.5	0	0
166	424.9	420.8	422.9	-0.2	0	0
167	425	421.3	423.3	0.4	0	0
168	425	422.1	423.4	0.1	0	0
169	425	422.7	424.4	1	0	0
170	424.8	423.7	424.3	-0.1	0	0
171	424.9	420.5	423.3	-1	0	0
172	425	420.8	423	-0.3	0	0
173	425	420.6	422.9	-0.1	0	0
174	425	420.8	423.1	0.2	0	0
175	425	421.9	423.6	0.5	0	0
176	424.4	423.2	424	0.4	0	0
177	424.7	423.3	423.9	-0.1	0	0
178	424.9	423.4	424.3	0.4	0	0
179	424.8	422	423.7	-0.6	0	0
180	424.8	422.5	424.2	0.5	0	0
181	424.5	424	424.3	0.1	0	0