TECHNICAL REPORT 91-5

SEISMIC ACTIVITY NEAR THE V.C. SUMMER NUCLEAR STATION

FOR THE PERIOD

JULY - SEPTEMBER 1991

BY

PRADEEP TALWANI
Principal Investigator

DEPARTMENT OF GEOLOGICAL SCIENCES
UNIVERSITY OF SOUTH CAROLINA
COLUMBIA, S.C. 29208

CONTRACT NO. 91-475-M

TECHNICAL REPORT 91-3

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PRADEEP TALWANI
Principal Investigator

Kusala Rajendran
and
Champa Madineni

DEPARTMENT OF GEOLOGICAL SCIENCES
UNIVERSITY OF SOUTH CAROLINA
COLUMBIA, S.C.29208

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INTRODUCTION

Analysis of the seismic activity near the V.C. Summer Nuclear Station in South Carolina between July 1 and September 30, 1991 is presented in this report. During this period, 18 events were recorded in the vicinity of Monticello Reservoir, 5 of which were located. The largest magnitude recorded during this period was M_L=1.5. There were two events of magnitude 1.5, both of which were located (Appendix V).

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 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 output is given in Appendix IV. The event magnitude was determined from the signal duration at JSC using the following relation:

$$M_L = -1.83 + 2.04 \text{ Log } D,$$

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):

$$\text{Log}_{10} E = 11.8 + 1.5 M_L$$

OBSERVED SEISMICITY DURING JULY-SEPTEMBER

During this period 18 earthquakes were recorded of which 5 were located (Figure 2). The located events were of poor quality (C or D). There were two events of magnitude M_L=1.5 which occurred on August 1 (20:00:09.89

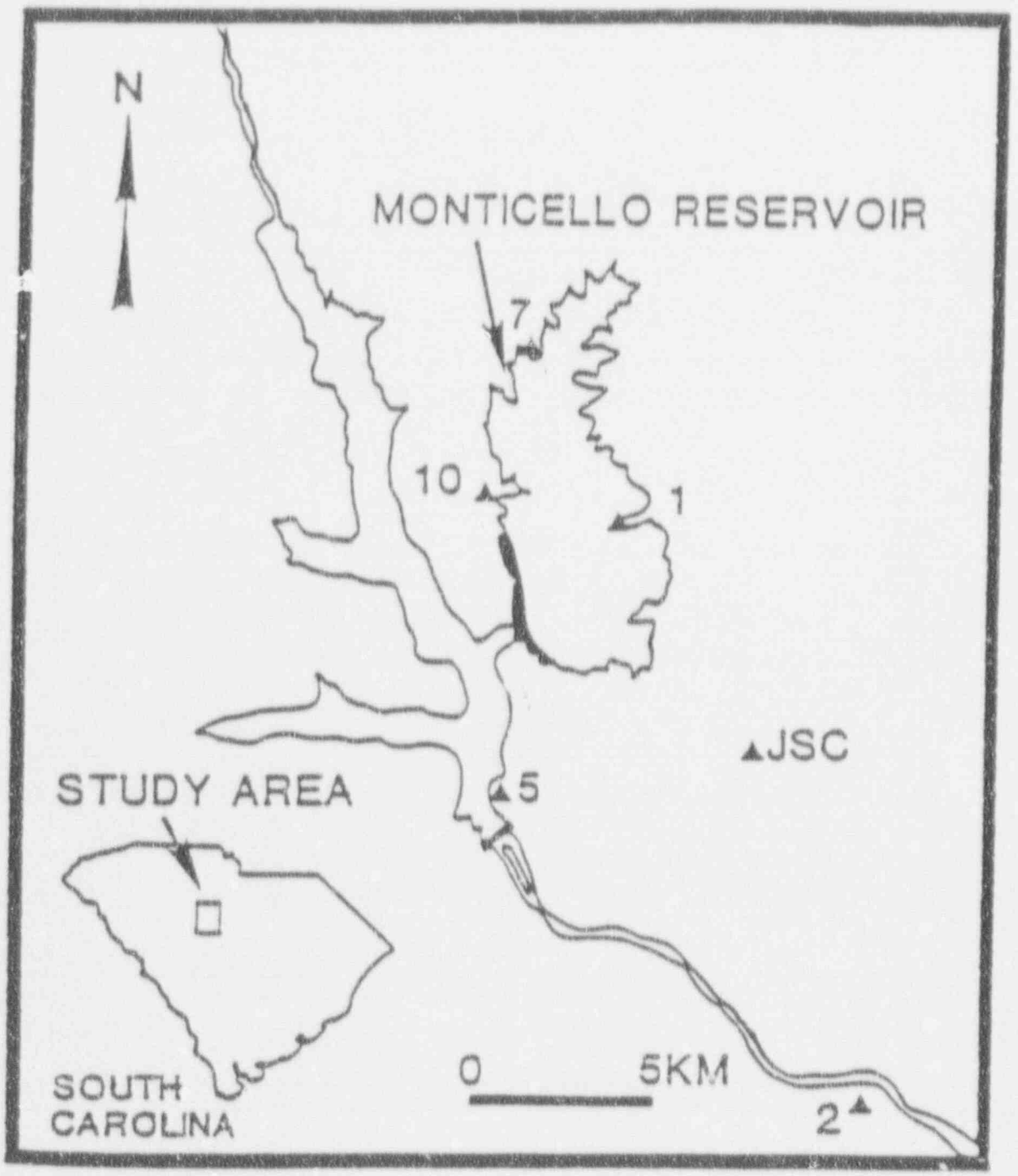

Figure 1 Location of Monticello Reservoir area showing seismic stations used in locating seismicity.

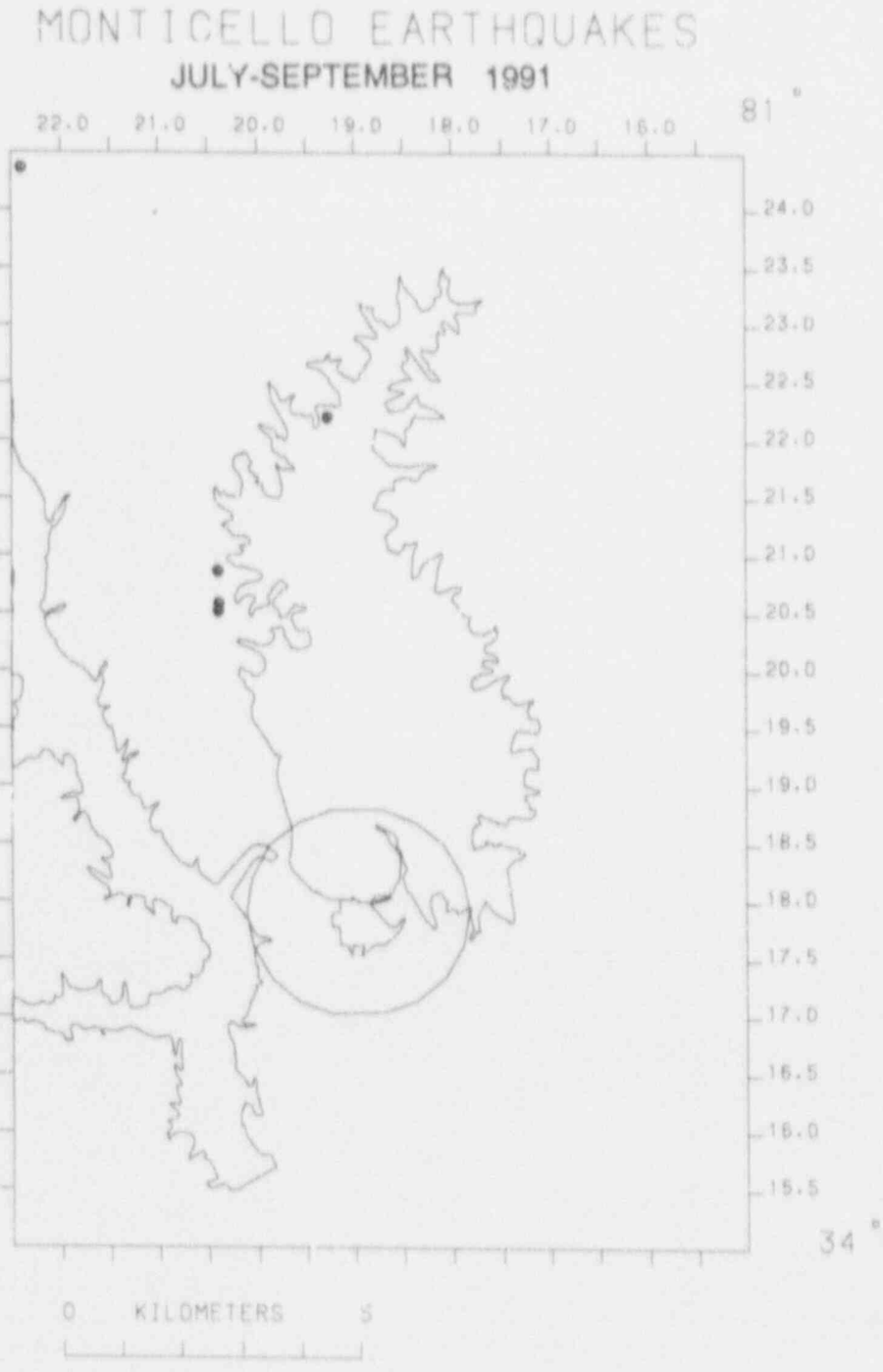

Figure 2. Earthquakes located near Monticello Reservoir during July-September 1991.

UTC) and September 9 (19:21:48.56 UTC). Additionally two other events of magnitude between 1.0 and 1.2, occurred during this period, of which the one on July 27 was located (Appendix V). The other, on July 31 was recorded only on two stations and was not located (Appendix VI). There were five other events of magnitude between 0 and 1, and of these two were located.

Twelve of the 18 events recorded this quarter occurred in a 9 day period between July 25 and August 3. They occurred in two temporally adjacent sequences. There were four events between July 25-27 of which three, all occurring on July 27, were located and found to lie on the western periphery of the reservoir. Eight events occurred between July 30 and August 3. Only one of these, a magnitude 1.5 event on August 1 was located. Its epicenter is to the northwest of the reservoir. Whether this is a microearthquake or a blast at a nearby quarry could not be confirmed.

The long term decline in seismicity observed at Monticello is continuing (Figure 3). The seismicity at Monticello seems to have leveled off 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 Appendices V and VI. The average water level, daily changes in water level, number of earthquakes and energy release are given in Appendix VII. No systematic correlation was observed between the seismicity and reservoir level fluctuations.

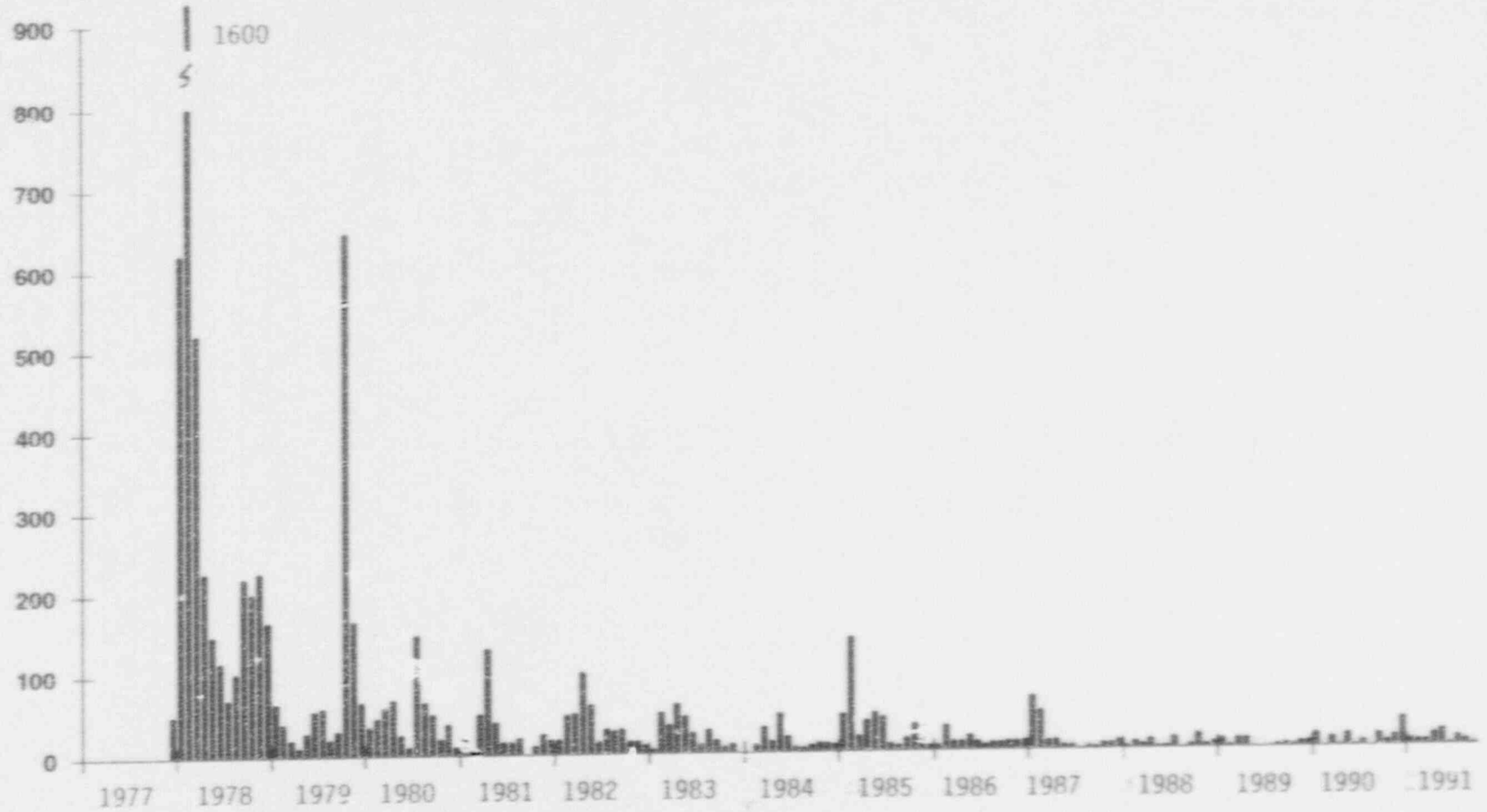

Figure 3. Earthquakes between impoundment and September 1991.

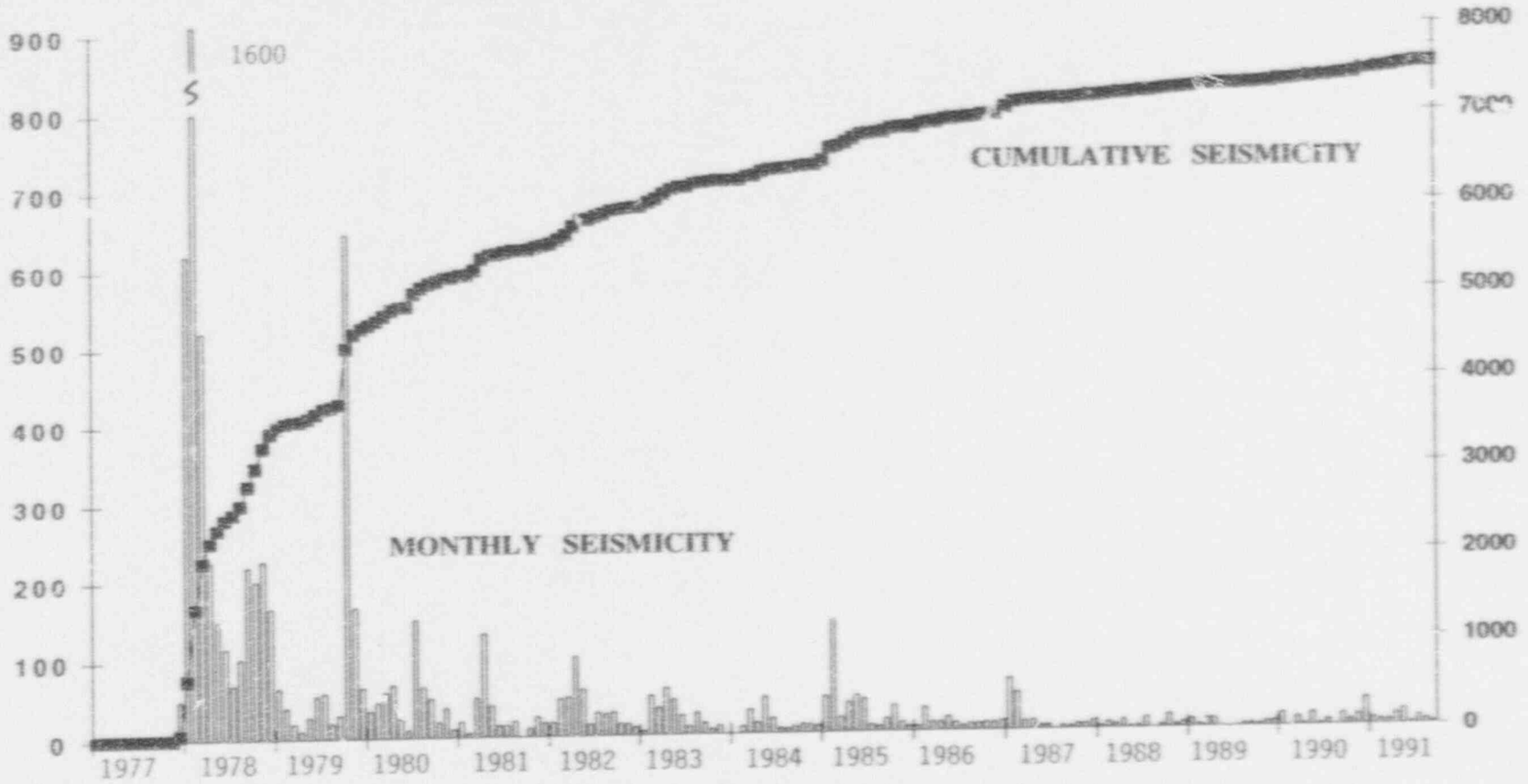

Figure 4. Monthly seismicity (bars) and cumulative seismicity line near Monticello Reservoir since impoundment.

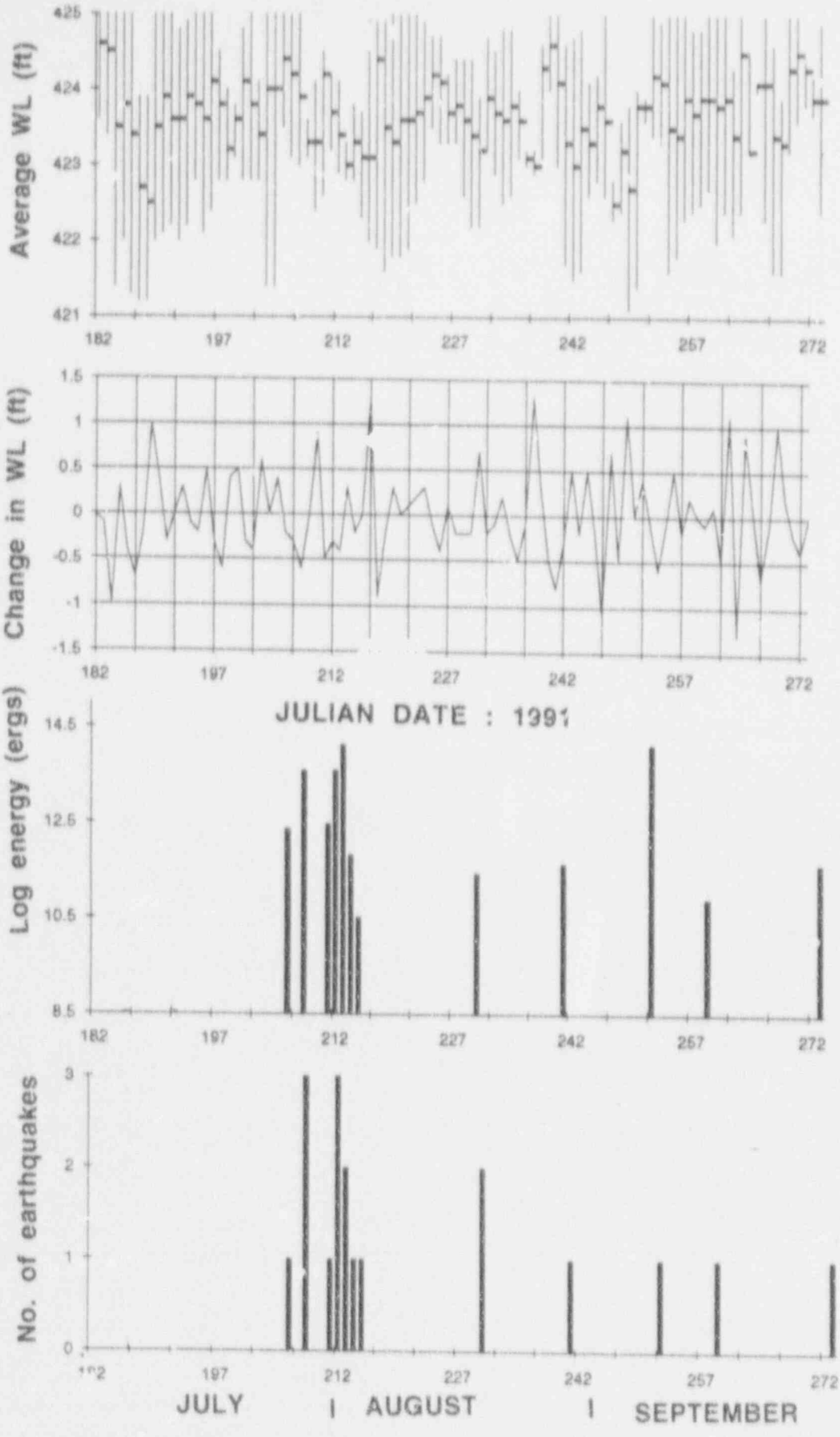

Figure 5. Comparison of daily lake level, variations in lake level, number of earthquakes and log of energy release (ergs per day) at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in reservoir level.

CONCLUSIONS

The level of seismicity during the third quarter was lower, compared to the previous quarter. The largest recorded magnitude was M_L=1.5. There were two events of magnitude M_L=1.5, both of which were located. The located events were to the north and northwest of the reservoir. 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.

APPENDIX I

STATION LOCATIONS

STATION	LAT° N	LONG °W
JSC	34°16.80′	81°15.60′
001	34°19.91′	81°17.74′
002	34°11.58′	81°13.81′
005	34°16.05′	81°20.05′
007	34°22.23′	81°19.50′
010	34°20.18′	81°20.25′

APPENDIX II

SEISMIC STATION OPERATIONAL STATUS
JULY 1-SEPTEMBER 30, 1991

STATION	PERCENT DOWNTIME
JSC	0
001	0
002	0
005	0
007	30
010	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/No, where R_i is the time residual for the ith 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 EARTHQUAKES

JULY-SEPTEMBER 1991

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
91 07 27	0203 10.49	34-20.83	81-20.35	3.18	0.82	8	214	1.2	0.09	0.9	0.8	C1
91 07 27	0751 47.88	34-20.64	81-20.35	1.75	1.02	8	214	0.9	0.16	1.6	1.4	C1
91 07 27	0752 43.49	34-20.62	81-20.35	1.00	0.73	5	214	0.8	0.12	2.3	3.2	C1
91 08 01	2000 00.89	34-24.36	81-22.44	2.10	1.54	5	337	5.4	0.04	2.2	4.6	C1
91 09 09	1921 28.56	34-22.26	81-19.42	0.85	1.54	7	311	4.0	0.13	1.7		D1

APPENDIX VI

LIST OF EVENTS WITH S-P ≤ 2.5 SEC RECORDED AROUND MONTICELLO RESERVOIR DURING1 JULY1991-30 SEPTEMBER 1991

DATE	STATION	P-ARRIVAL TIME H MIN SEC	S-P SEC	EP.DIST S-Px8.5km	DUR(S)	MAG
91 07 25	010	13 17 41.60	*	*	12.0	0.4
91 07 30	010	10 20 52.80	0.3	02.6	13.0	0.4
91 07 31	010	05 48 52.20	0.5	04.3	05.9	-0.2
*	*	09 46 12.50	*	*	03.2	-0.9
*	*	13 35 01.20	2.5	21.3	30.0	1.2
*	JSC	* 02.50	0.4	03.4		
91 08 01	*	05 30 05.30	0.4	03.4	05.2	-0.4
91 08 02	*	15 53 25.90	*	*	08.5	0.5
91 08 03	*	20 32 19.30	*	*	03.5	-0.8
91 08 18	*	08 19 11.70	*	*	04.0	-0.6
*	*	09 30 19.10	0.9	07.7	05.9	-0.6
91 08 29	*	14 14 11.50	*	*	07.2	-0.1
91 09 16	*	06 14 25.50	0.3	02.6	04.4	-0.6
91 09 30	*	10 37 28.00	0.3	02.6	07.6	-0.1

* Event is very close to the station; (S-P) not clear.

Appendix VII

Maximum and minimum water levels, change in water level, number of earthquakes and energy release (ergs per day) at Monticello Reservoir during July 1-September 30,1991. Dates are given in Julian Calender.

A		C	D	E	F	G
DATE	WL(max)	WL(min)	WL(avg)	CHANGE	NO.Eqs	Log E
182	425	423.6	424.6	0	0	0
183	425	423.4	424.5	-0.1	0	0
184	425	421.4	423.5	-1	0	0
185	425	422	423.8	0.3	0	0
186	425	421.3	423.4	-0.4	0	0
187	423.9	421.2	422.7	-0.7	0	0
188	423.9	421.2	422.5	-0.2	0	0
189	425	422	423.5	1	0	0
190	425	422.1	423.9	0.4	0	0
191	425	422.2	423.6	-0.3	0	0
192	424.8	422	423.6	0	0	0
193	424.9	422.2	423.9	0.3	0	0
194	425	422.8	423.8	-0.1	0	0
195	425	422.1	423.6	-0.2	0	0
196	425	422.4	424.1	0.5	0	0
197	424.5	422.8	423.8	-0.3	0	0
198	424	422.8	423.2	-0.6	0	0
199	423.8	423.1	423.6	0.4	0	0
200	424.8	422.8	424.1	0.5	0	0
201	425	422.8	423.9	-0.3	0	0
202	424.1	422.8	423.4	-0.4	0	0
203	425	421.4	424	0.6	0	0
204	425	421.4	424	0	0	0
205	425	423.5	424.4	0.4	0	0
206	425	423.1	424.2	-0.2	1	12.36
207	425	423	423.9	-0.3	0	0
208	423.6	423.1	423.3	-0.6	3	13.57
209	424.1	422.4	423.3	0	0	0
210	424.5	422.6	424.2	0.9	0	0
211	424.2	423.2	423.7	-0.5	1	12.46
212	424.1	422.9	423.4	-0.3	3	13.57
213	423.3	422.8	423	-0.4	2	14.11
214	423.8	422.8	423.3	0.3	1	11.82
215	423.7	422.3	423.1	-0.2	1	10.51
216	424.5	422	423.1	0	0	0
217	424.9	421.9	424.4	1.3	0	0
218	424.9	421.6	423.5	-0.9	0	0
219	425	421.8	423.3	-0.2	0	0
220	425	421.8	423.6	0.3	0	0
221	425	421.9	423.6	0	0	0
222	425	422.5	423.7	0.1	0	0
223	424.9	422.8	423.9	0.2	0	0
224	424.7	423.5	424.2	0.3	0	0
225	424.7	423.3	424.1	-0.1	0	0
226	424.2	423.3	423.7	-0.4	0	0
227	424.4	423.3	423.8	0.1	0	0
228	424.4	422.6	423.6	-0.2	0	0

A	B	C	D	E	F	G
229	424.4	422.2	423.4	-0.2	0	0
230	423.9	422.2	423.2	-0.2	2	11.44
231	424.7	423.2	423.9	0.7	0	0
232	424.5	422.9	423.7	-0.2	0	0
233	424.8	422.5	423.6	-0.1	0	0
234	424.8	422.6	423.8	0.2	0	0
235	424	423.1	423.6	-0.2	0	0
[illegible]	423.2	423	423.1	-0.5	0	0
237	423.2	422.9	423	0.1	0	0
238	424.6	423.1	424.3	1.3	0	0
239	425	424	424.6	0.3	0	0
240	425	423	424.1	-0.5	0	0
241	424.6	421.7	423.3	-0.8	1	11.64
242	424.7	421.5	423	-0.3	0	0
243	424.8	421.6	423.5	0.5	0	0
244	424.1	422.6	423.3	-0.2	0	0
245	424.2	422.8	423.8	0.5	0	0
246	425	422.6	423.6	-0.2	0	0
247	422.8	422.3	422.5	-1.1	0	0
248	423.6	422.4	423.2	0.7	0	0
249	423.8	421.1	422.7	-0.5	0	0
250	424	421.4	423.8	1.1	0	0
251	423.9	423.6	423.8	0	0	0
[illegible]	425	423.4	424.2	0.4	1	14.11
253	424.9	423.3	424.1	-0.1	0	0
254	425	421.6	423.5	-0.6	0	0
255	425	421.8	423.4	-0.1	0	0
256	425	422.3	423.9	0.5	0	0
257	424.8	422.4	423.7	-0.2	0	0
258	424.8	422.5	423.9	0.2	0	0
259	425	422.7	423.9	0	1	10.9
260	425	422	423.8	-0.1	0	0
261	425	422.4	423.9	0.1	0	0
262	424.3	422.1	423.4	-0.5	0	0
263	425	422.4	424.5	1.1	0	0
264	424.5	424.1	423.2	-1.3	0	0
265	424.1	424	424.1	0.9	0	0
266	425	422.3	424.1	0	0	0
267	424.6	421.6	423.4	-0.7	0	0
268	423.9	421.6	423.3	-0.1	0	0
269	425	423.2	424.3	1	0	0
270	425	423.6	424.5	0.2	0	0
271	424.4	423.8	424.3	-0.2	0	0
272	424.2	423.7	423.9	-0.4	0	0
273	424.9	422.4	423.9	0	1	11.64