TECHNICAL REPORT 92-3

SEISMIC AC IVITY NEAR THE V.C. SUMMER NUCLEAR STATION

FOR THE PERIOD

JULY - SEPTEMBER 1992

BY

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CONTRACT NO. N574984

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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, 1992 is presented in this report. During this period, 9 events were recorded in the vicinity of Monticello Reservoir, 2 of which were located. The largest magnitude recorded during this period was $M_L \approx 1.0$. This earthquake was located outside the reservoir.

SEISMIC NETWORK

Earthquakes during this period were recorded on stations of Monticello Reservoir and South Carolina Seismic Network. The configuration of stations utilized to locate Monticello events is shown in Figure 1 and station coordinates — 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 (Lze 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):

$$Log_{10} E = 11.8 + 1.5 M_L$$

OBSERVED SEISMICITY DURING JULY-SEPTEMBER, 1992

Seismicity around Monticello Reservoir was generally low during this period. There was one event in August, and eight in September. Of these 9 events, 2 were located (Figure 2). The located events were of poor quality (C or D). The largest event in the quarter occurred on August 25 (17:04:57.66 UTC) and it had a magnitude $M_L = 1.0$. This event occurred to the northwest of the lake and was not well located. However, it is included in the analysis due to the uncertainty in location. The other located event of $M_L = 0.8$ (September 8, 1992) occurred to the east of the reservoir. The remaining seven unlocated events were of small magnitude ($M_L = -0.4$).

The long term decline in seismicity observed at Monticello Reservoir is continuing (Figure 3). The cumulative seismicity at Monticello Reservoir shows a 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 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.

CONCLUSIONS

The level of seismicity during the third quarter was slightly lower, as compared to the previous quarter. The largest recorded magnitude was M_L =1.0. Both of the located events lie outside 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.

Monticello Reservoir Seismic Network

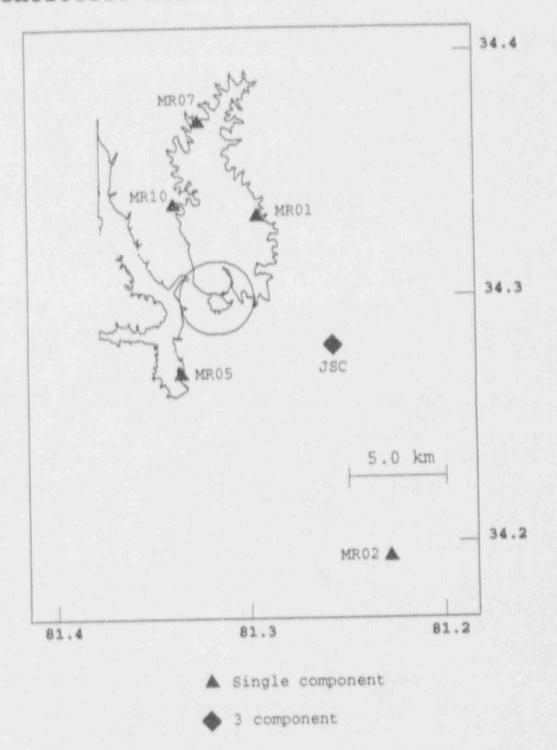


Figure 1 Location of Monticello Reservoir area showing seismic stations used in locating seismicity.

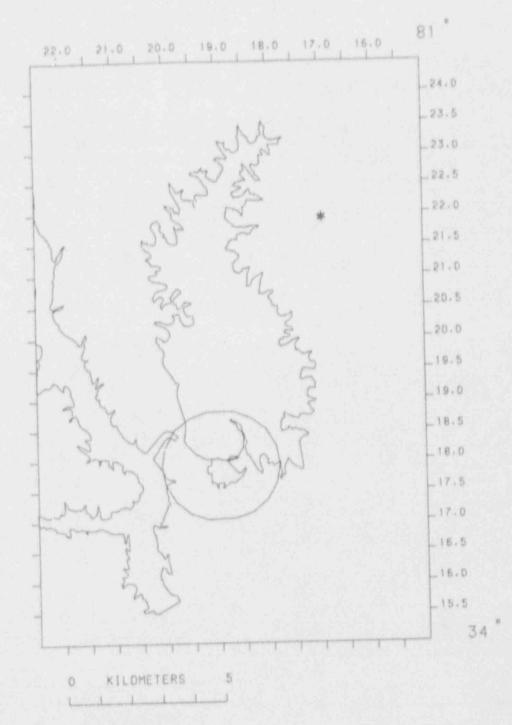
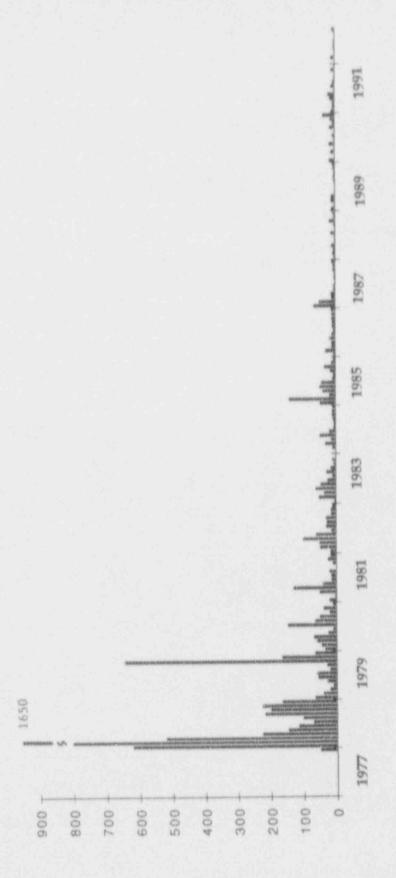


Figure 2. Earthquakes located near Monticello Reservoir during the period July-September, 1992



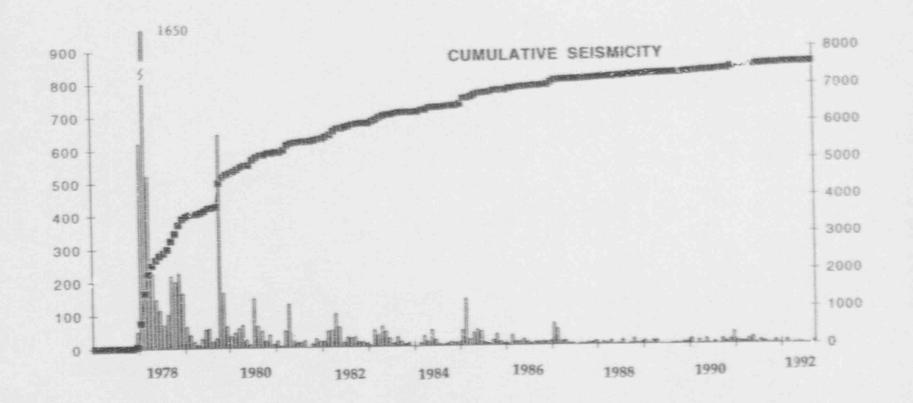


Figure 4. Monthly seismicity (bars) and cumulative seismicity (line) near Monticello Reservoir since impoundment.

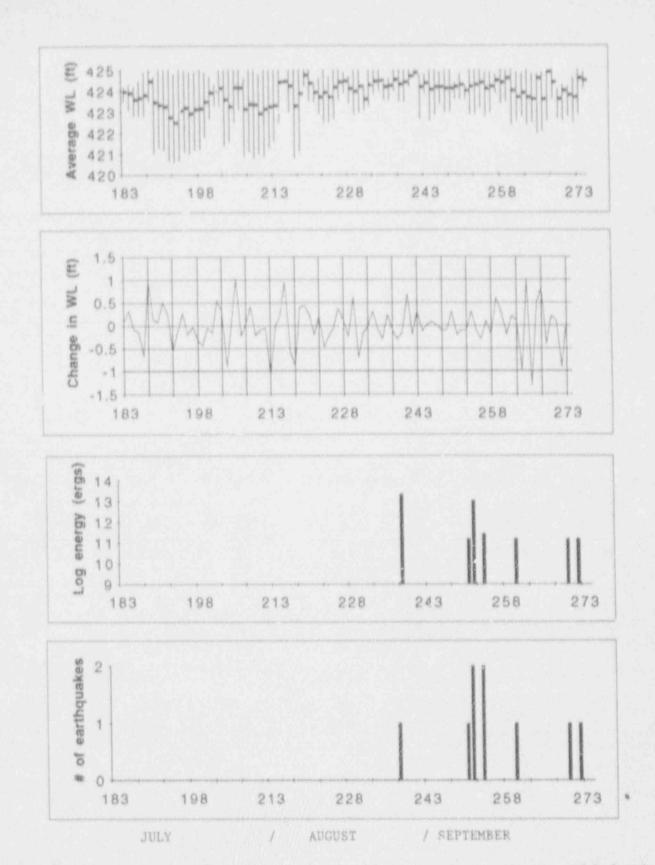


Figure 5. Comparison of daily lake levels, changes in lake level, number of earthquakes and the log of energy release (ergs per day) at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in water level

APPENDIX I STATION LOCATIONS

STATION	LAT° N	LONG °W
JSC	34°16.80′	81°15.60′
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 01-SEPTEMBER 30, 1992

STATION	PERCENT DOWNTIME
MR01	10
MR02	4
MR05	24
MR07	5
MR10	6
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	Cirigin 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_1^2/No , where R_i is the time residual for the ith station.
Columa	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 as unptions which may not be met in earthquake locations. Therefore standard errors may not represent a qual 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

JULY - SEPTEMBER 1992

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG							
920825	17 4 57.66	34-24.50	81-24.40	0.69	1.02	1	333	6.0	0.23	4 4	2.4	271
420908	1755 43.74	34-21.98	81-16.80	2.00	0.82	0	253	9.2	0.08	2.6	3.0	Sect

APPENDIX VI

Events with S-P \leq 2.5 s recorded around Monticello Reservoir during July - September, 1992

SL.NO	DATE	STATION	P-Arriv		S-P SEC	Ep.Dist(km) (S-P)X8.5	DUR	MAG
1	92 09 07	MR07	16:04	17.20	0.1	0.85	5	-0.4
2	92 09 08	MR07	07:48	48.70	0.2	1.7	5	-0.4
3	92 09 10	MR07	14:45	20.90	0.1	0.85	- 5	-0.4
4	92 09 10	MR07	15:46	27.70	0.1	0.85	5	-0.4
5	92 09 16	JSC	15:38	53.10	0.1	0.85	5	-0.4
6	92 09 26	MR07	04:46	36.60	0.1	0.85	5	-0.4
7	92 09 28		22:46	07.90	0.1	0.85	5	-0.4

Appendix VII

Maximum and minimum water levels, change in water level, number of earthquakes and log of energy release per day at Monticello Reservoir during July 1-September 30,1992. Dates are given in Julian Calender.

DATE	WL (max)	WL (min)	Average	Change	# eqs	Energy
183	424.2	423.5	424.0	0.068	0	0
184	424.3	423.1	423.9	0.316	0	0
185	424.2	422.8	423.6	PLEASE SHOW A REPORT OF THE RESIDENCE OF		0
186	424.5	422.8	423.7	-0.136	Action of Section (1997) and the Section of the	0
187	424.9	422.8		A variety of the format of the plant of the first	0	0
188	425	423.5		Married Company of the Company of th	0	0
189	424.7	421	423.5	A STATE OF THE PARTY OF T	According to Personal response on the Arthritish S	0
190	425	421.3	423.3	the second section of the sect	Control of the Contro	0
191	425	421.2	423.3		0	
192	425	420.7	422.8	A to a following to the contract of th	# TOTAL TOTAL CONTROL OF THE PROPERTY OF THE PARTY OF	C
193	424.8	420.6	422.5	-0.576		(
194	425	420.7	423.1	-0.12	0	0
195	425	421.1	423.2	0.276	0	0
196	424.9	421	422.9	-0.204	0	0
197	424.9	421.2	423.1	-0.032	0	0
198	425	421.2	423.2	-0.324	0	0
199	424.9	421.8	423.5	-0.437	0	0
200	Acceptable and the property of the property of the second	A STATE OF THE PARTY OF T	423.9	-0.051	0	0
201		423.3	A SERVICE OF SERVICE STATES AND ADDRESS OF THE SERVICE STATES AND ADDRESS	-0.16	0	(
202	According to the state of the s	423.3	Employee Device to Section American	0.544	0	(
203	A track of the Street of the S	Britaning beauty with the Make Miller (1970)	Berlinstein der Stein Stein der Stein der Stein	0.32	0	(
204	A STATE OF THE PARTY OF THE PAR	 Budden started makes their value of the contract 	\$ THE REPORT OF STREET AND ADDRESS OF STREET	 	And the state of t	(
205			A THE RESIDENCE OF STREET STREET	Section of the Control of the Contro	And the state of t	(
206	A STATE OF THE PARTY OF THE PAR	423.1	424.1	1.004	The same of the sa	(
207	A CONTRACTOR OF STREET OF STREET OF STREET	 - placed AA Hookshoop Racif Addition (Notice) 	Andrews to come placement and comment of the	-0.228	0	(
208		421.1	423.4	0.024	0	(
209	A THE RESERVE AND A STREET AND	420.8	423.3	Annual Section Section 1997 Annual Control of the Printers of	0	(
210		Contract of the Contract of th	422.9	A THE RESIDENCE AND ADDRESS OF THE PARTY OF	0	(
211	425	420.9	Frank Carrest Committee Contraction (Contraction)	The state of the s		(
212	Annual to the second se	421.3	CONTRACTOR STATE OF THE PERSON NAMED IN	Except with the service and the desired for the	Branch and the second second second	(
213	A control of the same of the s	Enternment blank (Critical Street Line), et	A CONTRACT OF THE PARTY OF THE PARTY OF THE PARTY.	E CONTRACTOR DE LA SESTIMACIÓN	And the second second second second second	(
214	Description of the second second second second	Annual Company of the	Account of the Control of the State of the	Transcential contraction of the second secon	Services Contractory Carlo Contractory Contractory	(
215	A STATE OF THE PARTY OF THE PAR	THE R. P. LEWIS CO., LANSING MICH. LANSING MICH.	 Control of Assert Control of Control 	A reactive time entropy with first to be the entropy of	A Million Colors of Property Annual Colors of Colors (Colors Colors of Colors (Colors Colors of Colors (Colors Colors of Colors (Colors of Colors	(
216	A STATE OF THE OWNER OWNER OF THE OWNER OWNE	423	424.2	0.952	0	(
217	A STATE OF THE PARTY OF THE PAR	420.8	423.3	THE RESERVE THE PERSON NAMED IN COLUMN TWO	Annual Control of the	(
218	Annual control of the second distance of the	421.1	423.9	 Company of the Company of the Company	THE R. LEWIS CO., LANSING, MICH.	0. 10 (
219	A COMPANY OF THE PARTY OF THE P	424.2	424.8	*	Committee of the supplemental property of the	(
220	The state of the s	423.5	424.4	0.44	WOMEN STREET,	(
221	424.4	423.5	423.9	And continue contract the second contract of	Account of the Control of the Contro	
222	424.6	A TOTAL DESIGNATION OF THE PROPERTY OF THE PRO	423.7	-0.2	Section 2017	(
223	And the second control of the second control	422.5	423.9	0.204	0	
224	A CHARLES AND CONTRACTOR OF THE PARTY STREET, SELECTION OF THE PARTY STREET, SELECTION OF THE PARTY STREET, SELECTION OF THE PARTY SELECT	422.5	423.7	-0.468		Particle continues and taxable
225	A STATE OF THE PARTY OF THE PAR	422.7	424.2	-0.24	And the second designation of the second sec	
226	 He are account on comparing management of the reserve 	423.6	424.4	-0.056	A STATE OF THE OWNER, WHEN PERSON NAMED IN	THE R. LEWIS CO., LANSING MICHIGAN PRINCIPLES AND ADDRESS OF THE PARTY
227	The second secon	423.9	424.5	0.38	Control of the second of the s	A CONTRACTOR OF THE PROPERTY O
228	A CHARLES TO STATE OF THE PARTY	ENTAL PROPERTY AND ADDRESS AND ADDRESS OF THE PERSON OF TH	424.1	0.112	A STATE OF THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.	A THE RESIDENCE AND ADDRESS OF THE PARTY OF
229	A STATE OF THE OWNER, WHEN THE PROPERTY OF THE	The same recommendate of the contract of the c		The state of the s	AND THE RESERVE OF THE PERSON NAMED IN COLUMN TWO IS NOT THE PERSON NAMED IN COLUMN TWO IS NAMED I	The section is the second section of the second section of

0	0	0.62	424.2	423	425	230
0	0	-0.7	423.6	423.1	424.3	231
0	0	-0.172	424.3	423.3	425	232
0	0	-0.032	424.5	423.9	425	233
0	0	0.304	424.5	424	425	234
0	0	-0.056	424.2	423.6	424.6	235
0	0	-0.292	424.3	423.6	424.6	236
0	0	0.236	424.5	424	425	237
13.33	1	-0.104	424.3	423.5	425	238
0	0	-0.3	424.4	423.5	425	239
0	0	-0.158	424.7	424.2	425	240
0	0	0.682	424.9	424.7	425	241
0	0	-0.184	424.2	422.7	424.8	242
0	0	0.304	424.4	423.9	424.8	243
0	0	-0.12	424.1	422.6	425	244
0	0	0.008	424.2	422.9	425	245
0	0	0.08	424.2	423.4	424.9	246
0	0	0	424.1	423	425	247
0	0	-0.1	424.1	423	425	248
0	0	-0.1	424.2	423.6	424.4	249
0	0	0.3	424.3	423.6	424.8	250
11.19	1	-0.2	424	423.6	424.3	251
13.04	2	-0.1	424.2	422.9	425	252
0	0	-0.1	424.3	422.9	425	253
11.44	2	0.3	424.4	423.2	425	254
0	0	-0.1	424.1	422.8	424.9	255
0	0	-0.3	424.2	423	424.9	256
0	0	0.1	424.5	423.9	424.8	257
0	0	-0.2	424.4	423.4	425	258
0	0	0.6	424.6	423.5	425	259
11.19	1	0.3	424	422.4	425	260
0	0	-0.2	423.7	422.6	424.9	261
0	0	0.2	423.9	422.8	424.9	262
0	0	0.1	423.7	422.4	425	263
0	0	- 1	423.6	422.5	424.8	264
0	0	1	424.6	422	424.8	265
0	0	-1.3	423.6	422.1	424.9	266
0	0	0.5	424.9	422.6	424.6	267
0	0	0.8	421.4	423.6	425	268
0	0	-0.4	423.6	422.7	424.1	269
11.19	1	0.2	424	422.6	424.3	270
0	0	0.1	423.8	422.8	424.2	271
11.19	1	-0.9	423.7	422.5	424.6	272
0	0	0.1	424.6	422.9	425	273
0	0		424.5	424.1	424.9	274