University of Queensland

SEISMOLOGY GROUP

WIVENHOE DAM SEISMIC SURVEILLANCE PROJECT

INTERIM STATUS REPORT

FOR THE PERIOD

1 JANUARY 1983 THROUGH 30 JUNE 1983

COMPILED BY: DR JOHN M.W. RYNN

THE UNIVERSITY OF QUEENSLAND
DEPARTMENT OF GEOLOGY AND MINERALOGY
ST. LUCIA, QUEENSLAND, AUSTRALIA, 4067

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ST: LUCIA. QLD. 4067

FOR: THE CO-ORDINATOR GENERAL
PREMIER'S DEPARTMENT
STATE GOVERNMENT OF QUEENSLAND

FOR DISTRIBUTION AND DISCUSSION
AT THE PROJECT MEETING TO BE HELD

ON 12TH OCTOBER, 1983.

AT 2:00 p.m.

IN THE EXECUTIVE BUILDING
100 GEORGE STREET,
BRISBANE.
(ROOM 3.22)

1 July 1983

1: REPORT WDSSP-4 MAY 1981-DECEMBER 1982

Apologies are tendered for the late distribution of this report. This document was written in late December 1982-early January 1983 and some of the statements contained therein are attributable to thoughts at the time of writing. Consequently, there may be slightly different thoughts on some matters at this time due to continued operation of the project over the last six months.

2: TIME DEFINITION OF PRE-IMPOUNDING AND POST-IMPOUNDING STAGES

For Reservoir Induced Seismicity (RIS) studies, the two stages most relevant to seismological studies are the pre- and post- impounding stages. The obvious reason is so that the level and nature of seismic activity before and after filling of a dam can be explicitly compared. It is noted, however, that in a large number of RIS studies around the world such studies were begun after impounding (indeed when earthquake activity suddenly occurred). In our case, we have been fortunate that the seismicity studies began well before the completion of the dam. Although the filling of Wivenhoe Dam has not "formally" begun at this time, we have the cases of the closure of the Diversion Channel on 17.4.82 and the "natural" holding of water due to the recent rainfall since early May 1983.

Thus we have defined, for the purposes of seismic surveillance, the following stages in the project:

PRE-IMPOUNDING STATE 18 MARCH 1977 through 17 April 1982

POST-IMPOUNDING STAGE 18 APRIL 1982 ONWARDS

This is important when the level and nature of the seismic activity is correlated with other data, primarily hydrological such as Wivenhoe lake level, rainfall, etc. Note that this definition is not coincident with the various reports and previously defined "phases" of the project. Such phases were related to both calendar year and fiscal conditions.

This "definition of stages" will become apparent in the annual report for 1983 (Report WDSSP-5 covering the period January through December 1983; due for submission early in 1984), whereby the interpretation of seismic results will be detailed in both pre- and post- impounding stages, namely March 1977 through April 1982 and May 1982 through December 1983, respectively.

3: GENERAL PROJECT COMMENTS FOR JANUARY THROUGH JUNE 1983

All aspects of the project have continued with the same work effort during the last six months. The several planned aspects of involving the C.O.G. technician, Mr. John Pix, to take over some of the routine procedures of the project have been implemented. All these are now operating in a smooth manner.

The routine microearthquake surveillance, through operation of Sub-array F, and man-made blasting analyses are proceeding as normal. The collection and correlation of relevant hydrological data was begun in this period. Analysis of the refraction data continued.

4: PROJECT PERSONNEL

Slight changes in duties, previously related to some of the routine aspects of the project, were instituted in this period. Mr. Pix took over some of the initial collection of the seismic and blasting data from Mr. Cuthbertson (GSQ). Since early May 1983, Dr Rynn has supervised a University of Queensland Work Experience Trainee (Mr. G. Ruediger). This is at no cost to the project and to this time has been most successful in the dual role of training Mr. Ruediger in scientific data management and assisting the project in its analyses. Mr. C.J. Lynam of our Department continues to assist in supplying the seismic data from the University's Mt. Nebo (code BRS) seismograph station.

5: SEISMIC SURVEILLANCE

Operation of the four seismograph stations of the network's sub-array F (WFPM - Pine Mt; WFPL - Plainland; WFTG - Toogoolawah; WFMB - Mt. Brisbane: Fig. 1) has continued on an uninterrupted basis during this period.

Ten microearthquakes have been detected in the Wivenhoe region. Of these, four were located. Details of their parameters is given in Table 1 with epicentres plotted on Figure 2. Other unlocatable microearthquakes are listed in Table 2.

Two earthquakes were located within 100 to 200 km radius of Wivenhoe Dam. Details are given in Table 3 with epicentres plotted on Figure 3. With these events, data from the Q.W.R.C. stations at Boondooma and Awoonga Dams have also been used.

The Wivenhoe network data is still proving invaluable to the Seismology Group's continuing research on the seismicity of central and southeastern Queensland and northeastern N.S.W. In addition, Wivenhoe data has been used by the Bureau of Mineral Resources Earthquake Seismology section, Canberra, in their continuing study of earthquakes in eastern Australia (in particular for the northwestern part of N.S.W.). Such earthquakes recorded on the network include those on 25.1.83 (Fraser Is), 30.1.83 (Gayndah), 15.4.83 (Monto) and seven earthquakes that occurred in northeastern N.S.W.

6: BLAST MONITORING

This aspect of the project has continued to be a vital part of the seismic surveillance analysis. With the data collection and preparation being taken over by Mr. J. Pix, the Blast Log Sheets supplied monthly by the quarries are more regular than ever before and this has enabled the blast monitoring to be kept right up to date. For this period 70 extractive material quarries, 6 coal mines and 3 Wivenhoe associated projects have been monitored. The computer blast file is now complete through June 1983.

7: EARTH MODEL (REFRACTION PROFILES)

Analysis of all refraction data is proceeding as planned to define a preliminary earth model (crust and upper mantle structure) from the analogue data. Data preparation of the site locations, shot instants and tape data is well advanced. Four profiles are under study:

WHO between Wivenhoe and Somerset Dams within the (sedimentary) Esk Trough

WSD between Split-Yard Creek and Somerset Dam within the (metamorphic) D'Aguilar Block

WMQ between Moura and the Gold Coast

WNG between Nanango and the Gold Coast

Although it was planned to complete all field work related to this aspect by the end of 1982, two profiles have yet to be completed. These are WNG and WXX, a NE-SW profile across the D'Aguilar Block between Split-Yard Creek Dam and Moodlu Quarry (Caboolture). The reason for this latter profile is to obtain information on the structure of that part of the Wivenhoe region (namely the South D'Aguilar Block) within which the majority of microearthquakes have occurred.

The reasons behind the delay in completing the WNG profile were simple - insufficient blasts (seismic sources) in the latter part of 1982 (particularly in December 1982) due to unsuitable weather conditions for quarrying operation. In regard to the WXX profile, field work will be undertaken when the last scheduled blast at the Split-Yard Creek Dam quarry occurs.

8: CALIBRATION OF NETWORK

During the week 26-30 April 1983, all four microearthquake seismograph systems of the current network were calibrated in situ. It was considered far more scientifically desirable to calibrate the systems in the field environment with normal operating characteristics rather than in the laboratory at some reduced gain and different filter settings (i.e. different frequency response) which necessitates extrapolation of the data to the operating ragne. The background noise conditions in the field during this week of calibration were ideal - continuous rain with little or no wind creating a ground noise level about 12 db lower than average levels observed during the complete time of operation of the network.

The frequency response curves (i.e. plot of ground amplitude magnification versus frequency) at normal operating conditions are shown in Figure 4. The maximum operating gains for each system are given in Table 4. It is noted that in the more than six years of operation all systems have now exactly the same response as they had when initially delivered - indeed this attests to the reliability of these Sprengnether MEQ800 recorders and Mark Products L4C vertical seismometers. In addition, when corrected for different operating gain levels (noting all systems use the same filter settings), all systems have the same frequency response curve both in shape and amplification.

9: ASSOCIATED DATA FOR THE PROJECT

As the project is now in the (seismically defined) post-impounding stage, the acquisition of various associated data was begun during this period. These data include:

- Wivenhoe Lake Level Data (from Q.W.R.C., Wivenhoe Dam)
- Wivenhoe Dam Rainfall data (from Q.W.R.C., Wivenhoe Dam)
- Split-Yard Creek Dam Rainfall data (from S.M.E.C., Split-Yard Creek Dam)

- Split-Yard Creek Dam Ground Water Observation Holes Data (from Q.W.R.C., Wivenhoe Dam)
- Somerset Dam Lake Level Data (from B.C.C., Somerset Dam)
- Radon Gas Emission Data at Two Ground Water Observation Holes at Split-Yard Creek Dam (Our project and Radiation Unit, Royal Brisbane Hospital)

The need for this data (as is normal practice for reservoir induced seismicity (R.I.S.) studies) is such that, in the event of an earthquake during this post-impounding stage, the occurrence of the event can be compared with the temporal distribution of each of the above data sets to determine if correlations exist. These data are now an integral part of the project and will continue to be collected and analysed.

The radon gas emission experiment was initiated between Dr. Rynn and Mr. G. Taylor, Chief Physicist with the Royal Brisbane Hospital. In the event of earthquakes, and more particularly related to the stress build-up in the crustal rocks in the vicinity of the hypocentre, several lines of research at overseas institutions (including several with similar R.I.S. studies to ours) seem to indicate that there may be a change in the rate of emission of radon from the surface rocks at the time of an earthquake. The project is fortunate in that the ground water holes at Split-Yard Creek Dam are ideal for this type of experiment. In addition, Mr. Taylor has modern equipment for analysing the samples. Two holes are used, PH55 on the roadway above the power house which is within the Eastern Border Fault Zone and PH56 near the Split-Yard Creek Dam spillway in the metamorphic D'Aguilar Block rocks. At present a sample of about 8 l. of air at a depth of about 2 m in these holes is taken (i.e. air is drawn out from the surface rocks at this depth and <u>not</u> the atmosphere) and values of radon gas content (in ppm) determined. This is an ongoing study and the results will be used in the same manner as those for the other associated data. This aspect of the project has been added at no additional cost to the overall project.

10: NEW MICROEARTHQUAKE SYSTEMS

Four additional microearthquake systems ordered by the Premier's Department were delivered about the middle of June. These systems were inspected and tested at the University of Queensland and await installation in the Wivenhoe region (planned for later in 1983).

11: PUBLICATIONS

A volume of the University of Queensland Department of Geology Papers containing five papers (Introductory Comments on WDSSP, Rynn and Webb; Wivenhoe Swarm of 15.5.77, Rynn; Esk Earthquake of 26.4.78, Rynn and Webb; Split-Yard Creek Blast of 4.12.78, Rynn and Webb; Tent Hill Earthquakes of 24.3.81, Rynn) is currently in press. A detailed paper on the entire pre-impounding stage of the WDSSP (March 1977 through April 1982) is in its final stages of preparation for submission to the ANCOLD Journal.

12: CONTINUING STUDIES FROM JULY THROUGH DECEMBER 1983

The following aspects of the project are to be pursued in the latter half of 1983:

(1) Continued seismic surveillance of the Wivenhoe region

(2) Continued routine collection and processing of data related to man-made blasting, hydrology, meteorology and radon emission. (6 months)

(3) Completion of the refraction profiles Nanango-Gold Coast and Split-Yard Creek Dam - Caboolture (4-6 weeks)

(4) Processing of all refraction data to define a first-approximation earth model through travel-time curves (from analogue tape data) (6 months)

(5) Commencement of acquisition of digital data to begin more detailed studies of earth models fro the region. ?

(6) Deployment of the new microearthquake instruments to extend the Wivenhoe seismograph network.

(7) Publications in preparation:

A magnitude formula for the Wivenhoe region (Rynn and Cuthbertson)

Current state of stress distribution in the South D'Aguilar Block (Rynn and Day).

All aspects of the research undertaken from January to December 1983 and the state of seismicity in the Wivenhoe Region for this period will be detailed in the Annual Report WDSSP-5 due for submission early in 1984.

TABLE 1: PRELIMINARY MICROEARTHQUAKE LOCATIONS IN WIVENHOE REGION

ORIGIN TIME (UT)		EPICENTRE		DEPTH	MAG	L	Q	R
DATE	HR:MN:SEC	°S LAT	°E LONG	(KM)	(MD)		(H-Z)	
1983 JAN 21	22:37:58.95 (39?)	27.5	152.9	10	0.8	A	2.5	4
APR 06	02:06:43.25	28.162	152.639	6	2.2	C	3.5	5
08	00:04:46.91	27.7	153.2	10	0.4	B	3.5	5
10	23:12:55.84	27.7	153.0	10	0.9	B	3.5	5

L : Location Factor for epicentre

A - within microearthquake sub-array
B - 0<r<35 km : outside microearthquake sub-array
C - 35<r<100 km

Q : Quality Factor for hypocentral solution

H - epicentral error in km
Z - focal depth error in km

R : Zones of seismic activity

1 - Wivenhoe Region
2 - Wivenhoe Swarm Zone
3 - Esk Trough
4 - D'Aguilar Block
5 - Ipswich-Beaudesert-Gold Coast
6 - Brisbane City
7 - North Coast
8 - Darling Downs

TABLE 2: UNLOCATABLE MICROEARTHQUAKES IN WIVENHOE REGION

APPROX. ORIGIN TIME (UT) DATE HR:MN	EPICENTRAL LOCALITY	MAG (MD)	REMARKS
1983 JAN 17 17:24	Toogoolawah	-0.8	Near station TG
FEB 04 01:28	Toogoolawah	-0.3	Near stations TG, MB
APR 06 02:19	Boonah	0.8	Aftershock to event at 02:06
11:37	Toogoolawah	0.5	Near station TG
11:38	Toogoolawah	0.0	Near station TG
MAY 16 16:42	Somerset Dam	-0.3	Near station MB

TABLE 3: PRELIMINARY EARTHQUAKE LOCATIONS 100-200 KM FROM WIVENHOE DAM

ORIGIN TIME (UT)		EPICENTRE		DEPTH	MAG	LOCALITY
DATE	HR:MN:SEC	°S LAT	°E LONG	(KM)	(MD)	
1983 MAR 02	12:58:31.74	26.176	153.420	10	2.2	East of Noosa
MAR 24	07:21:08.51	27.879	153.589	10	1.4	Gold Coast

TABLE 4: MAXIMUM FREQUENCY RESPONSES OF NETWORK SEISMOGRAPHS

STATION		OPERATING CONDITIONS		MAXIMUM GAIN AT FREQUENCY
CODE	NAME	GAIN	FILTER (LO/HI)	
WFPM	Pine Mt.	90 db	5/10 Hz	294000 at 10 Hz
WFPL	Plainland	84 db	5/10 Hz	105000 at 10 Hz
WFTG	Toogoolawah	90 db	5/10 Hz	194000 at 10 Hz
WFMB	Mt. Brisbane	84 db	5/10 Hz	133000 at 10 Hz

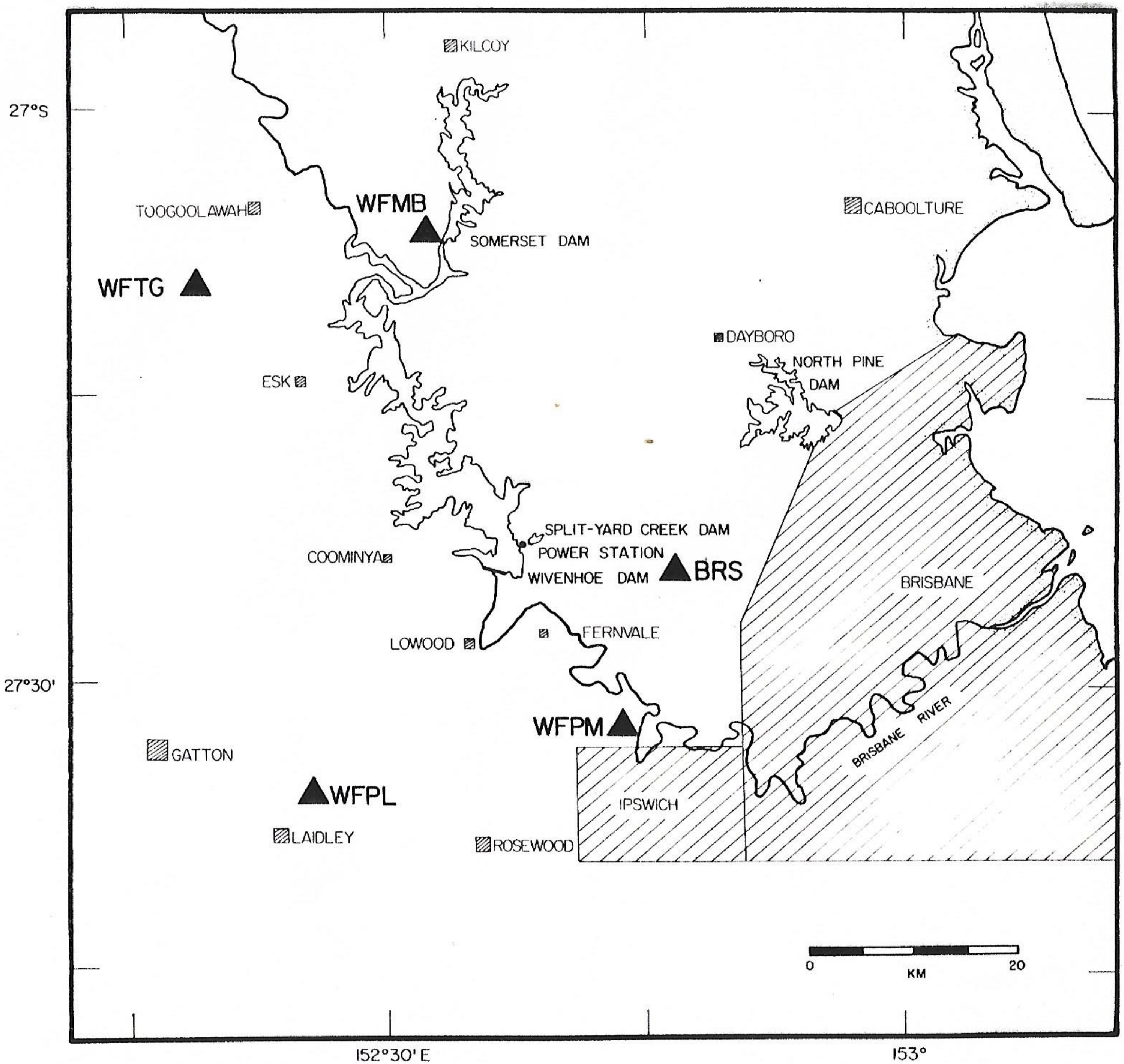

FIGURE 1: WDSSP seismograph network Sub-array F stations and University of Queensland standard seismograph station BRS

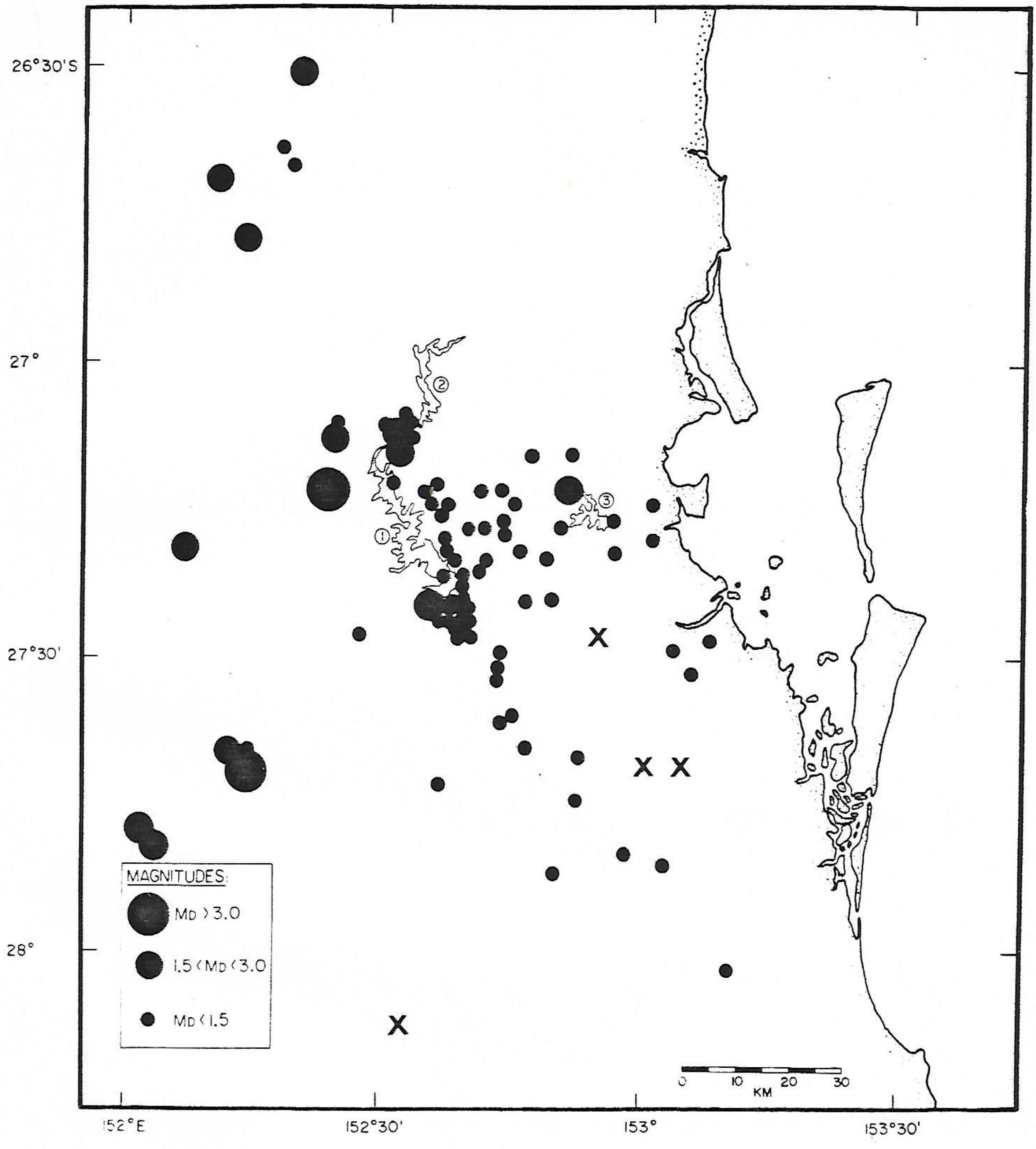

FIGURE 2: Epicentral map of microearthquakes located in the Wivenhoe region, March 1977 through June 1983. Events located during the first six months of 1983 are indicated by crosses.

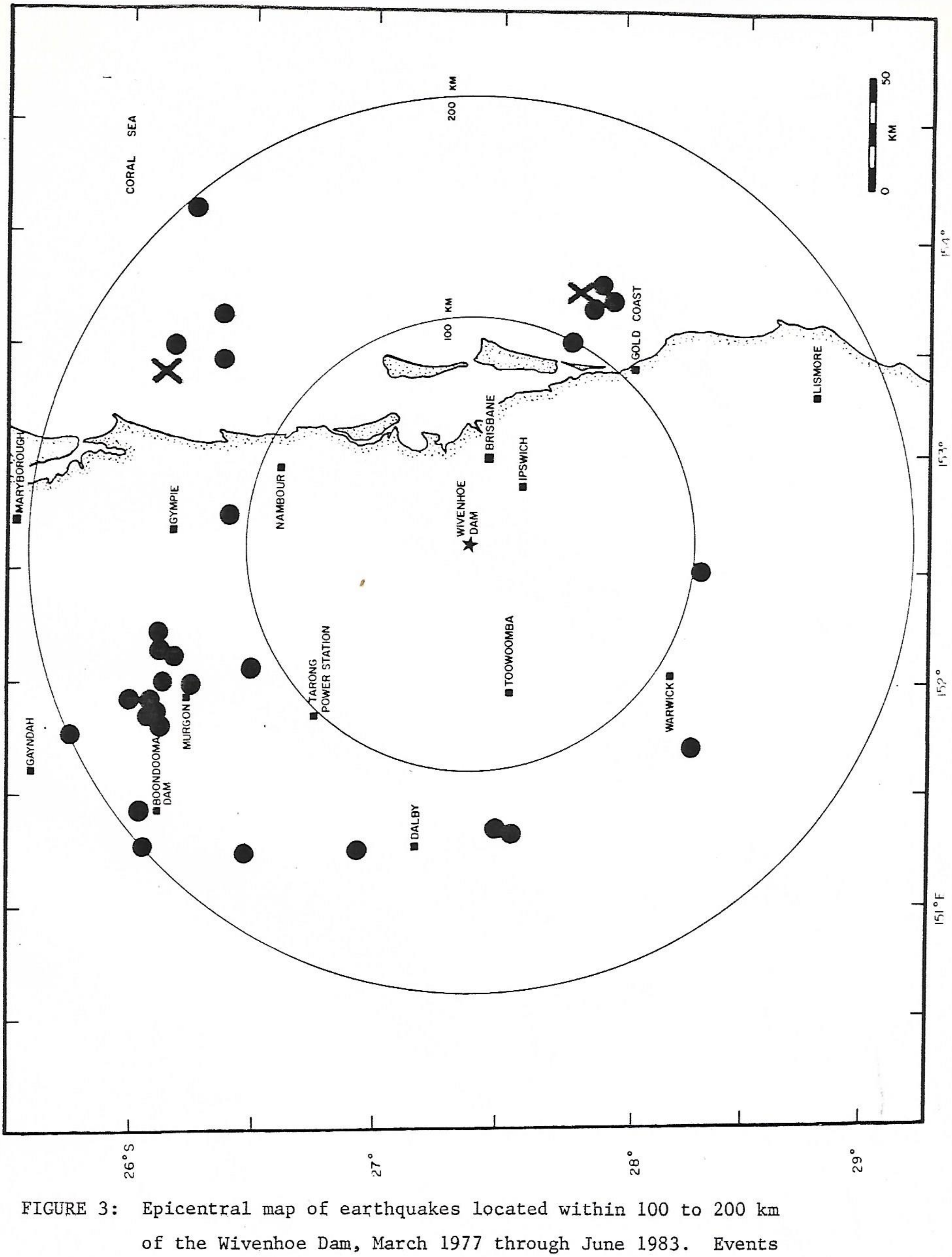

FIGURE 3: Epicentral map of earthquakes located within 100 to 200 km of the Wivenhoe Dam, March 1977 through June 1983. Events located during the first six months of 1983 are indicated by crosses.

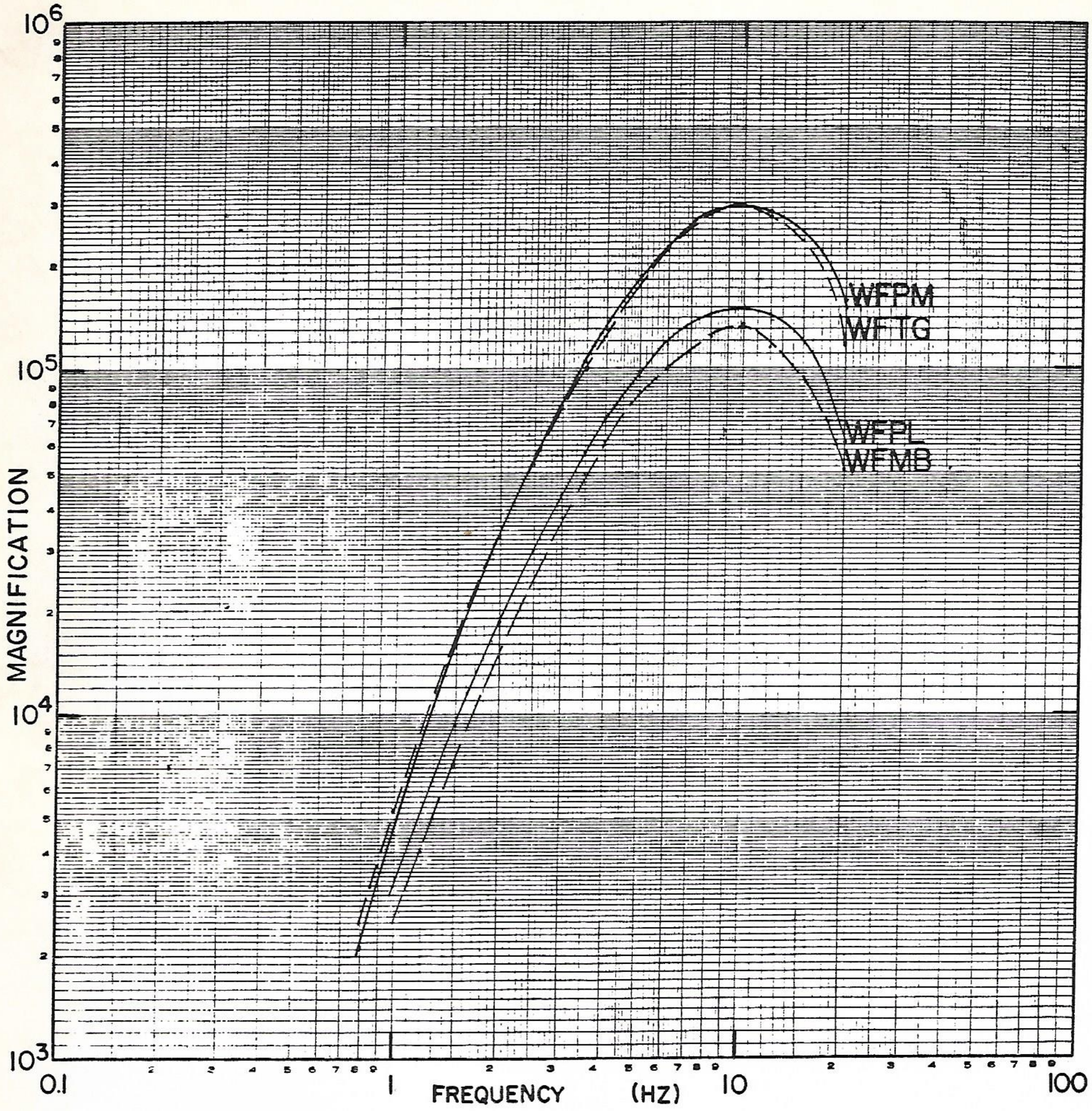

FIGURE 4: Frequency response curves for microearthquake systems of the Wivenhoe Dam Seismograph network