FINAL TECHNICAL REPORT: 1988

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Summary

This is the final technical report for USGS Joint Operating Agreement 14-08-0001-A0266 'Regional Seismic Monitoring in Western Washington' which covers network operation, routine data processing, and preparation of bulletins and reports. The objective of our work under this operating agreement is to gather data for use in evaluation of seismic hazards in western Washington and to support research carried out under contract 14-08-0001-G1390 'Earthquake Hazard Investigations in the Pacific Northwest', as well as other projects. This report includes a review of station operations during the contract period, and an update on recent changes in our data acquisition and processing system.

Since 1984, we have issued quarterly bulletins for all of Washington and the northern part of Oregon. These include catalogs of earthquakes and blasts located in Washington and Northern Oregon, providing up-to-date coverage of seismic and volcanic activity. Appendix 1 is composed of quarterly bulletins covering the operating agreement period.

Operations

Twenty-eight stations covering much of western Washington are supported under this operating agreement. The locations of the stations are given in Table 1, and shown in Fig. 1. All stations are north latitude and west longitude, and coordinates are given in degrees, minutes and seconds. The University of Washington digitally records over 100 seismic channels or stations in a triggered mode. Stations recorded include short and long period vertical components of WWSSN station LON and horizontal seismometers with Wood-Anderson-response at station SEA on the campus of the University of Washington.

At WWSSN station LON, six continuous photographic records were made daily until recently. These records, from three components of each short and long period instruments, were developed at the University of Washington. Since the end of 1986, only a few selected record of interest have been developed due to lack of funding. Also, the USGS no longer supplies the necessary materials, such as photographic paper, developer, and fixer. As a result of these circumstances, photographic recording at LON ceased in late 1988. We have continued to record two channels on helicorder at the UW, short and long period vertical components.

TABLE 1
Stations supported under USGS Joint Operating Agreement A0266

NAME	LAT	LONG	ELEV(km)	LOCATION
APW	46 39 6.0	122 38 51.0	0.457	Alpha Peak
BHW	47 50 12.6	122 1 55.8	0.198	Bald Hill
BLN	48 0 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
CMW	48 25 25.3	122 7 8.4	1.190	Cultus Mtns.
CPW	46 58 25.8	123 8 10.8	0.792	Capitol Peak
FMW	46 55 54.0	121 40 19.2	1.890	Mt. Fremont
GHW	47 2 30.0	122 16 21.0	0.268	Garrison Hill
GMW	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	47 12 11.4	121 47 40.2	1.305	Grass Mt.
HDW	47 38 54.6	123 3 15.2	1.006	Hoodsport
HTW	47 48 12.5	121 46 8.6	0.829	Haystack Lookout
JCW	48 11 36.6	121 55 46.2	0.616	Jim Creek
LMW	46 40 4.8	122 17 28.8	1.195	Ladd Mt.
MBW	48 47 2.4	121 53 58.8	1.676	Mt. Baker
MCW	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MEW	47 12 7.0	122 38 45.0	0.097	McNeil Island
NLO	46 5 18.0	123 27 0.	0.900	Nicolai Mt., Oregon
OHW	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OSD	47 49 15.0	123 42 6.0	2.010	Olympics - Snow Dome
PGW	47 49 18.8	122 35 57.7	0.122	Port Gamble
RMW	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RPW	48 26 54.0	121 30 49.0	0.850	Rockport
RVW	46 8 58.2	122 44 37.2	0.460	Rose Valley
SHW	46 11 33.0	122 14 12.0	1.423	Mt. St. Helens
SMW	47 19 10.2	123 20 30.0	0.840	South Mt.
SPW	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
STW	48 9 2.9	123 40 13.1	0.308	Striped Peak

Station NEW, the longest continuously operating station in Washington ceased recording at the UW in May of 1987 due to discontinuation of a phone link by the USGS. We had hoped to restore telemetry using the Bonneville Power Authority (BPA) microwave network, but difficulties developed and we are still negotiating with the BPA. Although neither LON nor NEW is supported under this agreement, their standing as older stations makes them important to network operations overall.

A summary of station history from November 1987 through October 1988 is given in Table 2 for stations operated under this operating agreement. No new stations were installed this year. Aside from station outages, normal maintenance includes a visit to each site every two years to replace batteries and a seismometer replacement every 4-6 years. In addition to the listed seismic stations, five radio telemetry relay sites must also

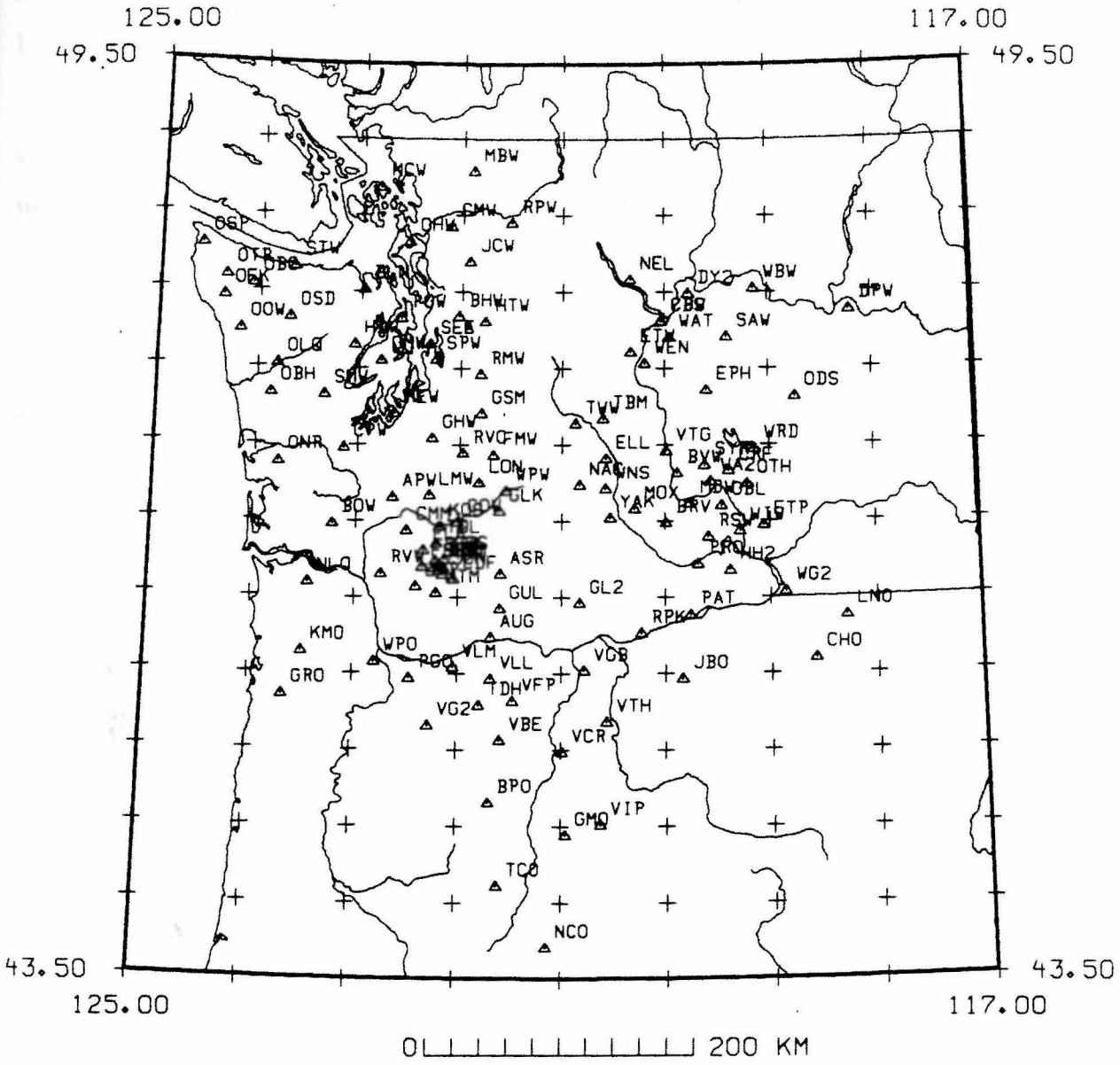

Figure 1. Map view of seismic stations supported under USGS JOA A0266 between Nov. 1, 1987 and Oct. 31, 1988. These twenty-eight stations provide coverage of western Washington.

be maintained. The semi-annual technical report under this contract covering the period 11/87-4/88 contains a description of our telemetry system.

Exceptionally mild weather during the winter of 1987-1988 allowed good station access, and helped to keep station operation at a near optimum level. The most significant outage was at OSD (Snow Dome) located on the Olympic Peninsula in a glacier-clad area high on Mount Olympus, far from any roads, and inaccessible except for a short period from mid-summer to early fall. In September of 1987, a solar panel was installed at the site with the hope of minimizing the number of future trips to change batteries. However on January 24 1988, OSD ceased operation, and was inaccessible until June 30. The outage was caused by loss of the solar panel from the antenna mast, likely due to extreme weather conditions. We reinstalled a solar panel, with additional precautions. A shorter outage at GMW and MEW from December 17 until Jan 5, was due to a cable which was pulled up at GMW. SMW (South Mountain) was struck by lightning on December 2, but was quickly repaired. A cable was damaged by animals at OHW (Oak Harbor), and had to be replaced, causing about 2 weeks of down time from February 6 - 19. Station GMW became intermittent in late October, due to seismometer tilt, and was repaired before the end of 1988.

A new seismometer and VCO, installed at station SHW (St. Helens) in October 1987, failed and were again replaced in November, although seismic coverage was unaffected since the original seismometer was running parallel with the new equipment. This was done to document the changed response and sensitivity so that uniform criteria for counts of seismic activity at Mt. St. Helens can be maintained. The long-standing interference problem at SHW was resolved by the new equipment. The interference resulted from a corroded and buried cable in the original seismometer-VCO combination.

Stations CMW, SHW, and MBW were converted to solar power during the summer. MBW had become intermittent in May, but was inaccessible until August. The problem at MBW proved to be premature battery failure of SAFT batteries. A similar problem occurred at HTW, which was intermittent from May until August. Premature failures of these SAFT cells caused a shortage of batteries.

TABLE 2
Western Washington Network
Major station outages and changes, November 1, 1987 - October 31, 1988

Station	Date	Comments
GMW	Dec. 17 1987 - Jan. 5 1988	Bad Cable
	Oct. - Dec. 9 1988	Intermittent or dead, seismometer tilt
HTW	May 1988 - Aug. 24 1988	Intermittent - Bad batteries
LMW	April 25 1988 - May 11 1988	Receiver damaged by lightning at GMW
MEW	Dec. 17 1987 - Jan. 5 1988	Bad cable at GMW
MBW	May 1988 - Aug. 20 1988	Intermittent - Bad batteries, solarized
PGW	Oct 21 1988 - Dec. 15, 1988	Bad batteries
OSD	Jan. 24 1988 - June 30 1988	Solar panel destroyed by severe weather
OHW	Feb. 16 1988 - Feb. 19 1988	Bad cable
SHW	Oct. 7, 1987 - Nov 18, 1987	Bad Seismometer

Data Processing

The seismographic network operated by the University of Washington consists of 122 short-period, vertical component, telemetered seismographic stations. The seismic recording system operates in an 'event triggered' mode, recording data at 100 samples per sec. per channel. The digital recording system is closely modeled after the CEDAR system developed at the California Institute of Technology by Carl Johnson. Arrival times, first motion polarities, signal durations, signal amplitudes, locations and possibly focal mechanisms are determined in postprocessing. Digital data are processed for all teleseisms, regional events, and all locatable local events. Each trace data file has an associated 'pickfile' which includes arrival times, polarities, coda lengths, and other data.

Our on-line seismic recording system was updated during 1988. Since 1980 a DEC PDP-11/34 has recorded incoming digital data, and a DEC PDP-11/70 has been used for analysis. In April 1988 a Masscomp-5600 minicomputer was acquired and installed by the U.S. Geological Survey at the University of Washington to take the place of the DEC equipment. By June 1, 1988 we had software running on the Masscomp computer to do both data acquisition and analysis tasks for the network. This software is a modified version of *RAVEN*, a specialized data acquisition system from NEWT Inc. By July, 1988 the software running on the Masscomp computer had taken over all acquisition and preliminary analysis tasks. The PDP-11/34 is still running as a backup system to the Masscomp. The Masscomp data acquisition system is a great advance over the PDP-

11/34 since it can record more channels of data and has a much greater capacity for unattended recording. Also, operating parameters can be changed while the system is running, data are recorded directly onto disk (instead of onto magnetic tape), and automatic post-recording processing begins as soon as the event is recorded. We are developing an alarm system that notifies seismologists when a sizable local earthquake occurs (includes a buzzer, and automatic telephone notification). For teleseisms, we are exploring the possibility of using the preliminary location to reactivate the recording system to record later phases which might not trigger the recording system on their own.

Publications

Publications supported under this operating agreement are listed in Appendix 2. Annual and quarterly catalogs are prepared jointly under this operating agreement and several others.

Acknowledgements

Laurens Engel performed the field and laboratory operation of all stations supported under this operating agreement. Ruth Ludwin merged Canadian data into the pick files, reformatted and relocated Oregon data, wrote reports, and handled miscellaneous administrative tasks. Rick Benson did routine seismic analysis for the entire network and compiled quarterly reports. Ivar Mundal assisted with routine processing and archiving of earthquake data. Chris Jonientz-Trisler helped compile data for quarterly reports.

APPENDIX 1

U. W. Seismic Network Quarterly Reports

87-D, 88-A, 88-B, 88-C

QUARTERLY NETWORK REPORT 87-D
on
Seismicity of Washington and Northern Oregon

October 1 through December 31, 1987

Geophysics Program
University of Washington
Seattle, Washington

This report is prepared as a preliminary description of the seismic activity in the state of Washington and northern Oregon. Information contained in this report should be considered preliminary, and not cited for publication. Seismic network operation in Washington and northern Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 14-08-0001-A0266
and
Grant 14-08-0001-G1390
and
Contract 14-08-0001-21978

and

U.S. Department of Energy
Contract DE-AM06-76RL02225
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INTRODUCTION

This is the fourth quarterly report of 1987 from the University of Washington Geophysics Program covering seismicity of all of Washington and northern Oregon. These comprehensive quarterlies have been produced since the beginning of 1984. Prior to that we published quarterlies for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program. In collaboration with the University of Washington, the State Department of Natural Resources (DNR) has published catalogs of earthquake activity in western Washington for the period 1970-1979. The DNR has published earthquake catalogs for the whole state for the period 1980-1986.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is preliminary, and subject to revision. Some earthquake locations may be revised if new data become available, such as P and S readings from Canadian seismic stations. Findings mentioned in these quarterly reports should not be cited for publication. Fig. 1 shows major geographical features in the state of Washington and northern Oregon and seismograph stations now in operation.

NETWORK OPERATIONS

Table 1 gives approximate periods of time when stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals, plus records of maintenance and repair visits. Fig. 1 shows a map view of stations operating during the quarter. No new stations were added except station CBS which was installed on December 7th to replace station CBW near Lake Chelan. Station NEW in eastern Washington (Newport) was closed due to funding cuts by the USGS. There are plans to reopen the observatory using telemetry to the University for recording.

On December 22, 1987 we were informed by the Department of Energy that because of the termination of the Basalt Waste Isolation Program at Hanford there would no longer be any support for the eastern Washington part of our network. The sudden cancelation of this long run-

ning contract effects 40 stations east of the Cascade Mountains and approximately 44% of the operational funding for the whole network. We have been given enough funds to continue operation through March 22, 1988. During this period we will reduce the number of stations in eastern Washington. We are currently trying to obtain support from other DOE programs for the operation of a greatly reduced number of stations in the east.

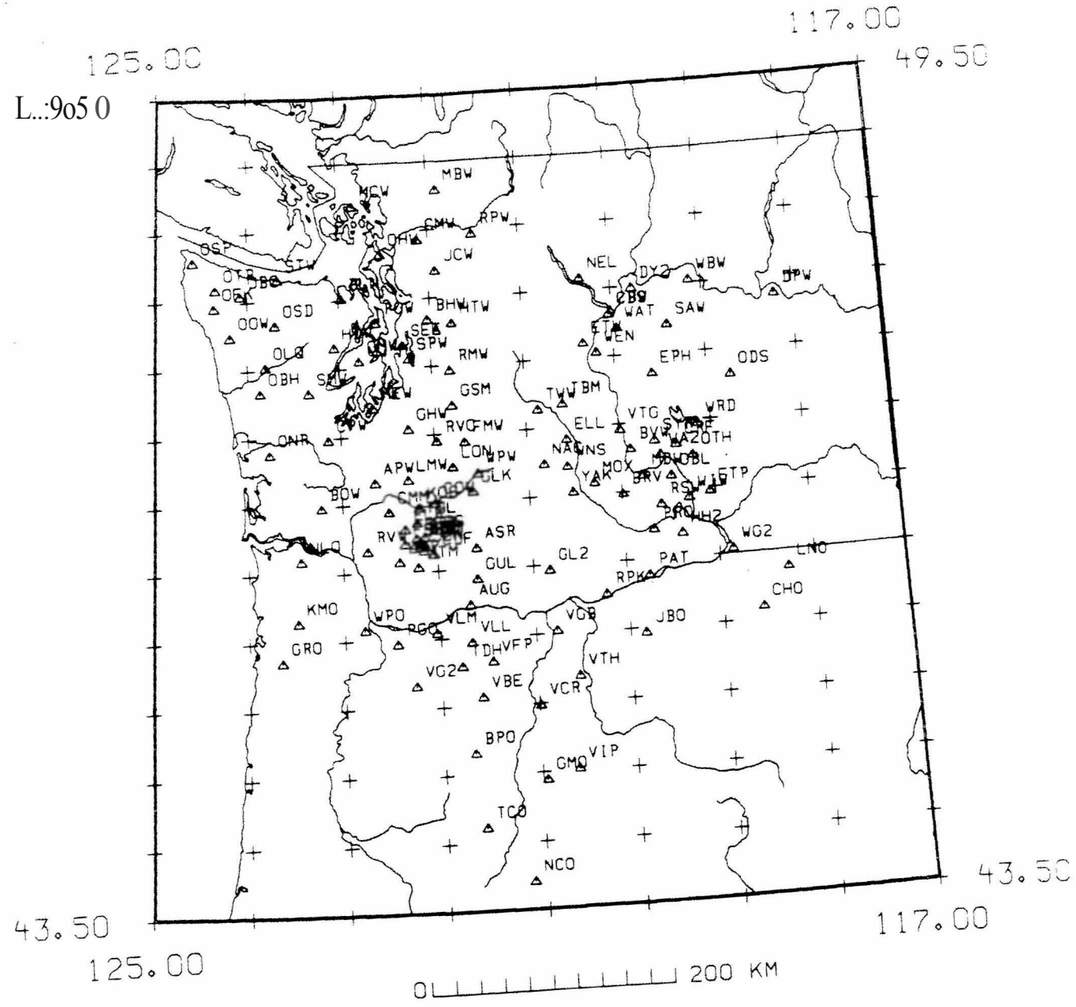

Figure 1. Seismograph stations operating during the 4th quarter 1987.

TABLE 1
Station Outages 4th quarter 1987

Station	Outage Dates	Comments
GMW	Dec. 15-Dec. 31	Dead
PGW	Whole Period	Intermittently noisy
MEW	Whole Period	Intermittent, low gain until Nov.1
SHW	Nov. 6-Nov.23	Dead
RVC	Oct. 8-Oct. 20	Dead
OHW	Oct. 20-Nov. 11	Intermittently noisy or dead
NEL	Nov. 23-Dec. 7	Dead
OBH	Oct. 20-Dec.31	Dead
OTH	Oct. 1-Oct. 27	Intermittently noisy or dead
CBW	Oct. 1-Oct. 27,Nov. 27-Dec. 7	Dead;replaced by CBS on 12/7
CBS	Oct. 1-Dec. 7	New station on 12/7
BPO	Dec. 15-Dec. 31	Intermittent
ETW	Nov. 23-Dec. 31	Dead
PRO	Oct. 8-Oct. 27	Intermittently noisy, unreadable
WG2	Whole Period	Intermittent, VCO problems
LVP	Oct. 20-Oct. 31	Intermittent, dead
NAC	Dec. 27-Dec. 31	Dead, problems at YAK
WNS	Dec. 27-Dec. 31	Dead, problems at YAK
REM	Oct. 1-Nov. 27	Dead, intermittent
CDF	Dec. 7-Dec. 9	Dead
YEL	Oct. 1-Nov. 27	Intermittent
OTR	Dec. 4-Dec. 31	Intermittent, mixing noise
OSP	Whole Period	Intermittently noisy, mixing noise
ONR	Nov. 6-Nov. 23	Dead
HSR	Dec. 15-Dec. 31	Dead
OBC	Whole period	Intermittently noisy, unreadable mixing noise
SOS	Intermittently	Wind noise
OTR	Dec. 4-Dec. 31	Intermittent, mixing noise
OLQ	Whole Period	Dead; phone line off
OFK	Whole Period	Intermittent; bad VCO
VLL	Oct. 8-Oct. 31	Intermittent
WPO	Oct 20-Oct. 31	Intermittent
AUG	Whole period	Intermittently dead,noisy
TDH	Nov. 27-Dec. 27	Intermittently dead
GRO	Nov. 27-Dec. 31	Intermittent
RPK	Oct. 31-Dec. 31	Intermittently dead
TCO	Oct. 20-Dec. 31	Intermittent, no subcarrier

STATIONS USED FOR LOCATION OF EVENTS

Table 2 lists stations used in locating seismic events in Washington and Oregon. Stations marked by an asterisk (*) were supported by USGS joint operating agreement 14-08-0001-A0266. Stations marked by ($) were supported by USGS contract 14-08-0001-21978. (+) indicates support under US Dept. of Energy contract DE-AM06-76RL02225. All other stations were supported from other sources.

The first column in the table gives the 3-letter station designator. This is followed by a symbol designating the funding agency, station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2
Stations Operating at the End of the Fourth Quarter 1987

STA	F	LAT	LONG	EL	NAME
APW	*	46 39 06.0	122 38 51.0	0.457	Alpha Peak
ASR	$	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	$	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BHW	*	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	*	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	*	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	$	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 29.4	0.925	Black Rock Valley
BVW	+	46 48 37.8	119 52 54.1	0.707	Beverly
CHO	+	45 35 27.0	118 34 45.0	1.076	Cabbage Hill, Oregon
CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
CBW	+	47 48 25.5	120 01 57.6	1.160	Chelan Butte
CDF	$	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	$	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	*	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
COW	$	46 29 27.6	122 00 43.6	0.305	Cowlitz River
CPW	*	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.9	119 46 13.0	0.884	Dyer Hill 2
EDM		46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	$	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 35.0	120 34 06.0	0.805	Ellensburg
EPH	+	47 21 12.8	119 35 46.2	0.628	Ephrata
ETP	+	46 27 53.4	119 03 32.4	0.250	Eltopia
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
FL2	$	46 11 47.0	122 21 01.0	1.378	Flat Top 2

continued

STA	F	LAT	LONG	EL	NAME
FMW	*	46 55 54.0	121 40 19.2	1.890	Mt. Fremont
FOX	+	48 19 50.0	119 42 29.0	0.896	Fox Mountain
GBL	+	46 35 51.6	119 27 35.4	0.330	Gable Mountain
GHW	*	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	$	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	$	44 26 20.8	120 57 22.3	1.589	Grizzly Mountain, Oregon
GMW	*	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GRO	$	45 21 04.5	123 39 43.0	0.945	Grindstone Mt., Oregon
GSM	*	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	$	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
HH2	+	46 10 18.0	119 23 01.0	0.490	Horse Heaven Hills (moved HHW)
HSR	$	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	$	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 36.6	121 55 46.2	0.616	Jim Creek
JUN	$	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	$	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	$	46 27 40.8	122 11 25.8	0.828	Kosmos
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LON		46 45 00.0	121 48 36.0	0.853	Longmire (WWSSN and DWWSSN)
LVP	$	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	*	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 48.0	119 45 39.0	0.330	Midway
MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
MTM	$	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 44 03.8	120 49 33.2	0.738	Naches
NCO	$	43 42 18.2	121 08 06.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 41.8	120 20 17.7	1.490	Nelson Butte
NLO	*	46 05 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OBC	$	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	$	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
ODS	+	47 18 24.0	118 44 42.0	0.523	Odessa
OFK	$	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OLQ	$	47 30 58.1	123 48 31.5	0.121	Olympics - Lake Quinault
ONR	$	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	$	47 44 12.0	124 11 22.0	0.743	Octopus West
OSD	*	47 49 15.0	123 42 06.0	2.010	Olympics - Snow Dome
OSP	$	48 17 05.5	124 35 23.3	-	Olympics - Sooes Peak
OTH	+	46 44 20.4	119 12 59.4	0.260	Othello
OTR	$	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 50.1	119 45 40.1	0.300	Paterson
PGO	$	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser

continued

STA	F	LAT	LONG	EL	NAME
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RMW	*	47 27 34.9	121 48 19.2	1.024	Rattlesnake Mt. (West)
RPK	+	45 45 42.0	120 13 50.0	0.330	Roosevelt Peak
RPW	*	48 26 54.0	121 30 49.0	0.850	Rockport
RSW	+	46 23 28.2	119 35 19.2	1.037	Rattlesnake Mt. (East)
RVC	$	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVW	*	46 08 58.2	122 44 37.2	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 03.6	0.690	St. Andrews
SEA		47 39 18.0	122 18 30.0	0.030	Seattle (Wood Anderson)
SEE		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (E)
SEN		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (N)
SHW	*	46 11 33.0	122 14 12.0	1.423	Mt. St. Helens
SMW	*	47 19 10.2	123 20 30.0	0.840	South Mt.
SND	$	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectif
SOS	$	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SPW	*	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
STD	$	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	0.308	Striped Peak
SYR	+	46 51 46.8	119 37 04.2	0.267	Smyrna
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
TCO	$	44 06 27.0	121 36 00.0	1.975	Three Creek Meadows, Or.
TDH	$	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	$	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TWW	+	47 08 17.2	120 52 04.5	1.046	Teanaway
VBE	$	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	$	44 58 58.2	120 59 17.3	1.015	Criterion Ridge, Oregon
VFP	$	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	+	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VIP	+	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	$	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	$	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTG	+	46 57 28.8	119 59 14.4	0.208	Vantage
VTH	+	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 24.2	119 33 45.5	0.230	Wahluke Slope
WAT	+	47 41 55.0	119 57 15.0	0.900	Waterville
WBW	+	48 01 04.2	119 08 13.8	0.825	Wilson Butte
WEN	+	47 31 46.2	120 11 39.0	1.061	Wenatchee
WG2	+	46 01 50.25	118 51 19.95	0.511	Wallula Gap
WIW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WNS	+	46 42 37.0	120 34 30.0	1.000	Wenas
WPO	$	45 34 24.0	122 47 22.4	0.334	West Portland, Oregon
WPW	+	46 41 53.4	121 32 48.0	1.250	White Pass
WRD	+	46 58 11.4	119 08 36.0	0.378	Warden
YAK	+	46 31 15.8	120 31 45.2	0.619	Yakima
YEL		46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens

EARTHQUAKE DATA

There were 501 events processed by the University of Washington digitally recording seismic network between October 1 and December 31, 1987. Locations were determined for 350 of these in Washington and Northern Oregon; 284 were classified as earthquakes and 66 as known or suspected blasts. The remaining 149 processed events include teleseisms (97 events), regional events outside the U. W. network (35), and unlocated events within the U. W. network. Unlocated events within the U.W. network include very small earthquakes and some known blasts. For example, only a few of the frequent mine blasts at Centralia are located. In addition, during eruptive phases of Mount St. Helens, we may locate only a representative sample of the earthquakes that occur under the volcano.

Table 3 is the catalog of earthquakes and blasts located within the network for this quarter. Fig. 2 shows all earthquakes with magnitude greater than or equal to 1.0 ($M_c \geq 1.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows all earthquakes located in western Washington ($M_c \geq 0.$) Fig. 5 shows all earthquakes located in eastern Washington ($M_c \geq 0.$) Fig. 6 shows earthquakes located at Mount St. Helens ($M_c \geq 0$).

Western Washington and Oregon

175 earthquakes were located between 43.5° and 49.5° north latitude and between 121° and 125° west longitude during the fourth quarter of 1987. Most of these occurred at depths less than 30 km with, as usual, a small number of earthquakes in the Puget Sound lowland at depths greater than 30 km. The deepest earthquake located during the quarter had a $M_c = 1.9$, and occurred at a depth of 51.5 km under Rosario Strait near Lopez Island in the San Juans. One earthquake was felt during the fourth quarter in western Washington. It occurred on October 2nd, and was $M_c = 2.6$ at a depth of 18.9 km. It was felt in Vancouver, Washington. This was also the largest event of the quarter in western Washington.

A cluster of seven earthquakes was recorded near Mt. Hood, Oregon during the fourth quarter. The largest earthquake in the cluster was a $M_c = 2.0$ earthquake on November 9. These

events were located at shallow depths (< 7km). The swarm started on November 4, and five of the earthquakes occurred on November 9th. The last event occurred on the 14th of November. Clusters of a few earthquakes have previously occurred in the same area, including a cluster of four earthquakes last quarter.

Eastern Washington and Oregon

During the fourth quarter of 1987, 109 earthquakes were located in eastern Washington. There were 2 moderate sized events larger than magnitude 4 in eastern Washington this quarter. The first event occurred on December 2 at 07:12 UTC (Dec. 1, 11:12 PST), and had a magnitude $M_c = 4.1$, and was felt over a wide area near Naches and Yakima. The second event occurred on December 2, at 09:02 UTC, (01:02 PST) and had a magnitude $M_c = 4.3$. This was somewhat more widely felt. Both were located 16 km northwest of Yakima and had a depth of about 18 km. There were a total of eleven earthquakes in this general area during this quarter. The Entiat area south of Lake Chelan was again active and eight earthquakes from magnitude 0.8 to 2.0 were located there at depths less than 12 km.

A swarm of six events occurred near Sims Corner, Wash., in the month of December. Sims Corner is in Douglas County southwest of Grand Coulee and just west of Banks Lake. The largest event had a magnitude $M_c = 2.7$ and was felt along with 2 small events less than magnitude 2. All had depths shallower than one km. The felt events all occurred on December 20.

Another swarm began on October 2 about 9 km. south of the town of Corfu, Wash. (50 km north of Richland). By the end of the quarter, there had been 52 events which had clustered into two pods of activity, separated by about two km. This swarm has continued into the first quarter of 1988. The largest events had magnitudes $M_c = 2.2$ on December 4 and December 30, and the smallest had a magnitude $M_c = 0.5$. Most had magnitudes less than 1.0.

Another swarm of five earthquakes occurred between November 19 and November 27, 15 km northeast of the town of Ellensburg. The largest (a $M_c = 2.1$), occurred on November 25. All had focal depths less than 5 km, and all had magnitudes averaging $M_c = 1.9$.

Five events occurred in October and November about 10 km north of the town of Richland, Wash. The largest event (a M_c = 2.0) occurred on October 7. Two more occurred on October 7 and 8. The other 2 events occurred on December 3 and 6, with magnitudes of 1.6 and 1.9, respectively.

Elsewhere in eastern Washington, earthquakes generally occurred as isolated events rather than in clusters.

Mount St. Helens Area

As of the end of this quarter, there has been no eruptive activity for the entire year of 1987, the first year this has been true since 1980. There has been, however, an increase in deep activity at Mount St. Helens during the last half of 1987. (Deep activity is considered to be earthquakes deeper than 3 km). In the fourth quarter alone, there were 20 earthquakes deeper than 3 km. On November 12, a M_c = 2.1 occurred; this is by far the largest deep earthquake to have occurred since the summer of 1980, and the largest earthquake during the fourth quarter at Mount St. Helens.

88 earthquakes were located in the Mt. St. Helens area during the fourth quarter of 1987, including the deep earthquakes.

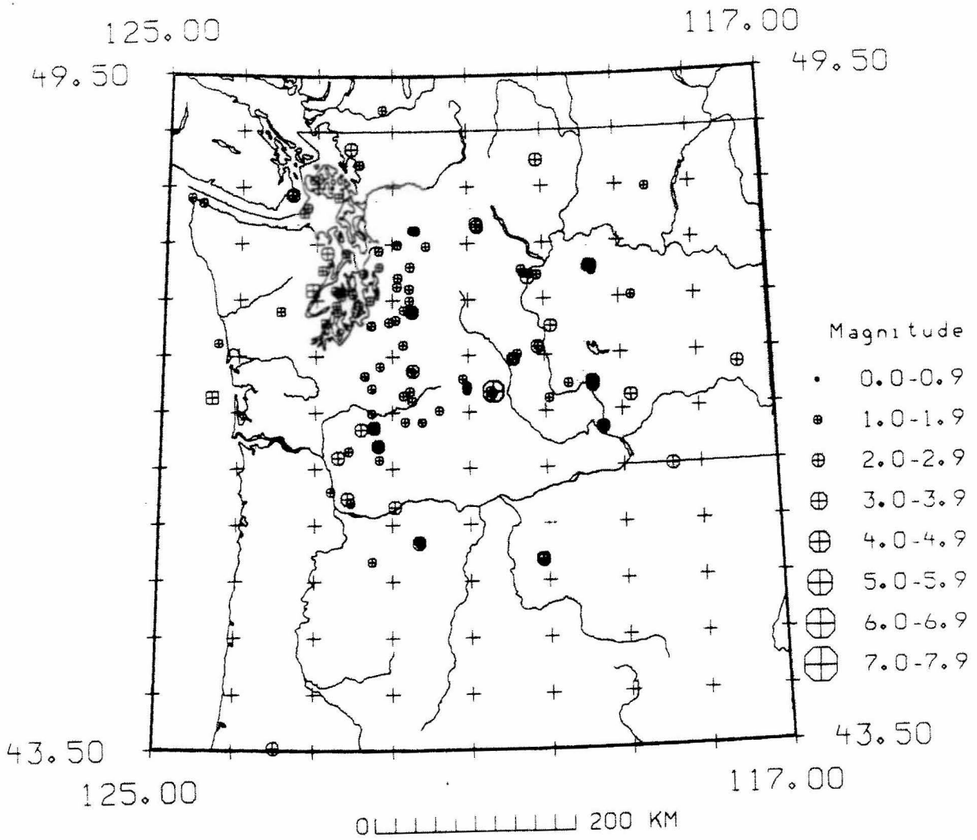

Figure 2. Earthquakes located in Washington and northern Oregon with magnitudes greater than 1.0, 4th quarter 1987. A square symbol indicates that a event located with a depth greater than or equal to 30 km. Octagonal symbols are used for events shallower than 30 km.