GEOLOGICAL SURVEY OF CANADA

OPEN FILE 3724

TRIAL SEISMIC HAZARD MAPS OF CANADA - 1999: 2%/50 YEAR VALUES FOR SELECTED CANADIAN CITIES

John Adams, Dieter H. Weichert, and Stephen Halchuk

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John Adams[1], Dieter H. Weichert[2], and Stephen Halchuk[1]

[1]National Earthquake Hazards Program,
Geological Survey of Canada
7 Observatory Crescent
Ottawa K1A 0Y3

[2]National Earthquake Hazards Program,
Geological Survey of Canada
9860 West Saanich Road
Sidney V8L 4B2

1999 July 05

107 pages, including 7 tables, 27 figures, and 5 Appendices

NOTE: This Open File replaces Open File 3283, issued in March 1996

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ABSTRACT

We summarize the methods being used for new seismic hazard maps of Canada, tabulate final values of the 50th and 84th percentile ground motions for major cities, and give uniform hazard spectra, all for sites on firm soil for both 10% and 2% probabilities of exceedence in 50 years. The availability of strong ground motion relations for spectral parameters allows computation of spectral acceleration maps, which are being recommended as input to the seismic provisions of the National Building Code.

RÉSUMÉ

Nous résumons les méthodes utilisées pour les nouvelles cartes de péril séismique du Canada, donnons les valeurs finales de mouvement du sol au 50e et 84e centile pour les villes importantes et donnons les spectres de péril uniforme, tout cela pour des sites sur sol dur et une probabilité de dépassement de 10% et 2% en 50 ans. Les relations de mouvements forts du sol pour les paramètres de spectre ainsi obtenus permettent de calculer des cartes d'accélération spectrale qui sont recommandées comme base des dispositions séismiques du Code National du Bâtiment.

INTRODUCTION

The Geological Survey of Canada is producing a suite of new seismic hazard maps for Canada. These maps, initially released for trial use and public comment in 1996 as GSC Open File 3283 (Adams et al., 1996), are being revised as appropriate and reissued in 1999 as the basis for seismic design provisions in the year-2001 edition of the National Building Code of Canada. Three generations of seismic hazard maps for Canada have been produced at roughly 15-year intervals (1953, 1970, 1985), and a fourth generation is now justified because there is sufficient new information available to improve the hazard estimates (Adams et al., 1995a; Basham, 1995).

The present open file is being issued to update key seismic hazard values computed using the methods that will form the basis of the "1999 Seismic Hazard Maps of Canada". It replaces GSC Open File 3283 "Trial Seismic Hazard Maps of Canada - 1995: Final Values for Selected Canadian Cities", which contained earlier values for the 10%/50 year probability level only. A list of changes and significant differences in the results is summarized in Appendix A1.

While it is still intended to issue a suite of open files to document the Method & Computational Aspects, Eastern Earthquake Source Zones, Western Earthquake Source Zones, and the Choice of Strong Ground Motion Relations, these have been delayed by the retirement of key staff. The current open file will be superceeded by a "Results" open file, when the documentation reports are issued.

The new hazard maps will incorporate a significant increment of earthquake data, recent research on source zones and earthquake occurrence, together with complementary research on strong ground motion relations. In contrast to the 1985 maps, which gave national values for peak ground velocity (PGV) and peak ground acceleration (PGA), we can now provide spectral acceleration values ("PSA"; 5% damped) for the range of periods important for common engineered structures. We present tables of hazard values for most of the larger population centres exposed to seismic hazards, as well as Uniform Hazard Spectra (UHS), all computed for sites on firm soil at the 10% and 2% probabilities of exceedence in 50 years (0.0021 and 0.000404 per annum, respectively). The 10%/50 year values are comparable to the 1985 seismic hazard maps, while the 2%/50 year values are likely to form the basis of the revised building code (Adams et al., 1999; Heidebrecht, 1999).

METHOD

Because this Open File is being issued in advance of the Open Files containing the full documentation, an overview is given below.

The present method for calculating seismic hazard builds upon the work of Basham et al. (1982; 1985) which established the third generation of seismic hazard maps for Canada. We apply the same Cornell-McGuire methodology (e.g., McGuire, 1993) using a customized version of the

FRISK88 hazard code (FRISK88 is a proprietary software product of Risk Engineering Inc.). This, and other new-generation codes, allow explicit inclusion, for the first time for a national hazard map of Canada, of both aleatory (randomness) and epistemic (model or professional) uncertainty (a brief account of uncertainty is given below). We note that because of revised computational parameters used in the program relating to the subdivision of the seismic zones into computational slices and to the interpolation of values, there have been some revised values as detailed in Appendix A1. We have also checked the hazard values from our customized version of FRISK88 against those produced by a newly released program (EZ-FRISK) from Risk Engineering Inc which runs on a PC; for the same best-estimate input parameters (EZ-FRISK lacks the treatment of epistemic uncertainty) the outputs are replicated. We will be documenting these trials in a later report.

Of necessity, eastern and western Canada must be treated slightly differently. In the following, the boundary between east and west is taken to slice diagonally across Canada from southeastern Alberta to the eastern Beaufort Sea.

Probability level

The probability level used in GSC Open File 3283 was 0.0021 per annum, or a 10% chance of exceedence in 50 years. This is the same as for the 1985 National Building Code maps. The current open file provides the 0.000404 per annum (2% chance of exceedence in 50 years, rounded subsequently in this report to "0.0004 p.a.") values, as well as the 0.0021 per annum values for backward comparability. For reasons detailed by Adams et al. (1999) and summarized in Appendix A4, it is currently considered more reliable to base design forces on this lower probability shaking, which is approximately the approximate structural failure rate deemed acceptable (Heidebrecht, 1999).

Cities

The "cities" in the list include most of the larger population centres exposed to seismic hazards, together with a few select localities to round-out the geographical distribution. Coordinates for the cities are given only to 0.1 degree. Final values in the Results open file will be given to 0.01 degree and will represent the town hall, chief post office, or downtown core, and not the airport or weather station, as is often the case in the current NBCC.

Uncertainty

A full treatment of uncertainty will be given in a subsequent Open File. Suffice it to say here that the new seismic hazard maps of Canada under preparation at GSC consider both types of uncertainty:

Aleatory uncertainty arises from physical variability that is inherent in the unpredictable nature of future events. For example there is a random component of earthquake source and propagation processes which will cause a scatter of amplitudes about the median values, even if the median were known with perfect accuracy. The Cornell-McGuire approach, as implemented in the 1985 NBCC hazard maps included the aleatory uncertainty by incorporating the "sigma" of the ground motion relations into the computation. The sigma is the standard deviation of the scatter of the data about the median ground motion relations, and its incorporation through the FRISK88 code increases the median hazard (the aleatory uncertainty is also included in all the percentiles of hazard).

Epistemic uncertainty arises from the differences in expert specification of modelling assumptions, unknown or only partially known parameters, and extrapolation beyond observed range of data. Examples are: specification of seismic source zones, including judgments on stochastic behaviour of historical seismicity, or belief in future activity of seismic gaps; assumptions made in calculations of recurrence curves, such as their analytical form, and extrapolation beyond the observed data range or duration of historical record; and choice of maximum magnitude. FRISK88 uses a standard "logic tree" approach to include the epistemic uncertainty. Our 84th percentile values include the contribution of the epistemic uncertainty from all the explicitly-included parameters (strong ground motion relations, focal depth, earthquake recurrence parameters, upper bound magnitude); a further parameter — earthquake source zone configuration — is treated separately, as discussed below.

The above separation into aleatory and epistemic is over simplified. In fact, any uncertainty that is not explicitly identified as an epistemic uncertainty will probably be lumped together with the aleatory. For example, the amplitude of ground motions from an earthquake depends on whether its mechanism is strike-slip or thrust, or on the directivity of the source. Current estimates of the uncertainty for Canada bundle this variability into the aleatory uncertainty (as the sigma); however if factored out, as additional parameters in the ground motion relations, the new sigma would be lower than before. Hence the separation of uncertainty into aleatory and epistemic is somewhat artificial.

SEISMICITY PARAMETERS

Earthquake Catalogue

We have used the Canadian earthquake catalogue up to 1990 for the east and up to 1991 for the west. Relative to the catalog used for the 1985 maps, this adds a significant increment of data, particularly in the Arctic. Our knowledge of the Canada-wide earthquake activity in more recent years indicates that reprocessing the source zones and recomputing their magnitude-recurrence relations to include more recent earthquakes would not change the hazard results significantly, although it might reduce the uncertainty slightly. Of more significance, we have also revised the location and magnitude parameters of older earthquake, and have supplemented the Canadian catalogue by recent U. S. catalogues. The eastern earthquakes chiefly have m_{bLg} magnitudes, so within the hazard program we converted them to moment magnitudes using the Atkinson (1993) relation for $m_N \leq 5.5$ and Boore and Atkinson (1987) for larger events, in order to use the Atkinson and Boore (1995) strong ground motion relations. The western earthquakes have a mix of magnitudes, depending on availability and quality, and are assigned in order of preference, moment magnitude for the largest, surface-wave magnitude for the next and so on; since the definition (or calibration) of these different scales are generally perceived to blend the scales smoothly into one another, we consider them equivalent to moment magnitudes in order to apply the Boore et al. (1993; 1994) and Youngs et al. (1997) relations.

Earthquake Source Zones

The last hazard maps were computed in 1982, using seismicity up to 1977 for most zones. They represented the distribution of seismicity by a single set of seismicity source zones. Since the 1982 maps, we have accumulated an additional decade and a half of earthquakes, and discovered clearer epicentre patterns in some places but been surprised by "unexpected" events in others. We have developed a better understanding of the seismotectonics behind the seismicity, but also an appreciation that much is unknown about how the future pattern of seismicity will resemble or differ from the historical pattern.

In some places, the Queen Charlotte Fault being an example, the level of knowledge is quite high, and one would expect a single model to suffice. In most other places, the range of opinions as to the cause and distribution of the earthquakes make a single model subject to much arbitrariness, so that the hazard results would reflect the current opinion of the compiler(s) and hence add a deterministic flavour to the maps. The resultant hazard maps might change drastically if there were a change of compiler, an "unexpected" earthquake, or a shift in the paradigm of earthquake occurrence. For these reasons we think a pair of models provides the minimal, but acceptable, representation of the diversity of opinion as to the causes and future locations of earthquakes.

To apply the Cornell-McGuire method we purchased a license for a large commercial program (FRISK88) in 1990 that allows us to use a number of source zone models and weight them by our (subjective) assessment that they are the correct model. For eastern Canada, our philosophy over the past 8 years has been shaped by the belief that while the scale of source zones could vary from the continent-scale to very small zones around single earthquakes, there are practical reasons for not choosing these extremes. Hence we have two models, a **H** model that in general uses relatively small source zones drawn around historical seismicity clusters, and a **R** model that establishes larger, regional zones (Fig. 1). The **H** and **R** models for the east were constructed by Adams and Halchuk, those for the west by Rogers and Horner. While some of the same philosophy is applicable in the eastern Rockies, the differences between the **H** and **R** models in western Canada are not generally interpretable in this manner, as neither expert in the west adopted a strongly historical model.

We have tried an approach proposed by A. Frankel of the USGS as part of their estimation of eastern U.S. earthquake hazard. From our perspective, the most interesting aspect of their method is the estimation of seismic hazard based on the historical occurrence rate of $M \geq 3$ earthquakes (Frankel 1995; 1996). We applied Frankel's computer code to our earthquake file (Halchuk and Adams, unpub., 1995) and found that it replicated the hazard from our eastern **H** seismicity model very closely (our **H** model results are the appropriate ones to compare because that model in the east is designed to estimate hazard from small, historical earthquake clusters). It is reassuring that the assumptions made during the design of the **H** model, and the simplifications adopted in the Frankel code, result in similar hazard across the border (Halchuk and Adams, 1999). Despite this, we have reservations about the current USGS method, particularly with respect to the estimation of seismic hazard for regions of low or negligible contemporary seismicity, such as the regions of eastern Canada where the **R** model dominates.

In eastern Canada, the **R** model often combines a number of seismicity clusters that are inferred to have a common cause into large source zones, the larger of which are the Arctic Continental Margin (ACM), the Eastern Continental Margin (ECM), and the Iapetan Rifted Margin (IRM), shown on Figure 1. For each, the **R** model zone implies that currently aseismic regions between adjacent seismicity clusters (e.g., the St. Lawrence valley near Trois-Rivières) are capable of large earthquakes, and that the rate of activity along the extensive zones (e.g., at any place along the continental margin) is constant, and is not higher in the vicinity of the historical activity. Contour maps of hazard computed using the **R** model have long 'ridges' of moderate hazard and lack the 'bulls-eyes' of high hazard produced by the **H** model (and exist in the current code maps). As a consequence, if the **R** model were implemented in a building code, it would reduce the protection significantly in regions of high historical seismicity while increasing protection only slightly in other places. This poses a dilemma to engineers concerned with safety. A probabilistic combination of the two models (as is possible with FRISK88) would involve their weighted-sum, but any weight given to the **R** model would reduce the protection in regions of high historical seismicity. Our proposed non-probabilistic solution is discussed below under "Combining diverse hazard estimates using the 'robust' approach".

In western Canada, while the tectonics are better understood, and the models are not as different, there are still differences of opinion. For example, model **R** collects crustal earthquakes around Vancouver and Seattle together with the central Vancouver Island earthquakes into one zone (CASR) to represent shallow seismicity in this region of the North American Plate above the Cascadia subduction zone; model **H** uses two smaller zones (see Fig. 1). The Queen Charlotte Fault is the only earthquake source treated as a fault; all others are area sources.

Magnitude Recurrence Parameters

We use the maximum likelihood method of Weichert (1980) to compute the magnitude recurrence parameters. To provide an estimate of epistemic uncertainty we have taken the standard errors for the calculation and combined them to give an upper and a lower curve which approximate one sigma (standard deviation) error bounds. The curves are asymptotic to an assumed upper bound magnitude, and again we have used our judgment to associate the three curves with three possible upper bound values. Examples for two eastern source zones are shown in Figure 2. For some zones, the numbers of earthquakes were small and the statistics poor, so we imposed a regional value of the slope parameter. The level of the recurrence curves is dominated by the number of small earthquakes, but for the hazard integration a lower magnitude cutoff of 4.75, near the magnitude of engineering interest, is used.

For a few zones we have tempered the strict mathematical fit by our judgement. The only case where this has had a dramatic effect on major urban areas was in the Strait of Georgia region. Figure 3 shows the magnitude-recurrence curves we adopted for the CASR zone. The lower curve, representing a maximum likelihood fit to the earthquakes larger than magnitude 2.5, underestimates the rate of M>6.7 earthquakes from the past hundred years by an order of magnitude. It is not known whether the large historical earthquakes are a statistical anomaly or whether the fitted model for the rates is incorrect. Therefore, in order to better match the rate of large earthquakes we neglected all earthquakes smaller than the hazard cutoff, magnitude 4.75, and made a second maximum likelihood fit; the result is the upper curve. This curve, if extrapolated to smaller magnitudes, would badly underestimate the rates of small earthquakes. However, these earthquakes do not contribute to the hazard, while the upper curve, by matching the historical rate of larger earthquakes, better represents the historical hazard. In terms of the three-fold representation of the magnitude recurrence curve we use with FRISK88, we weighted the lower curve at 0.16, and took the upper curve to be both the "best" and "upper" relations, for a combined weight of 0.84.

Probabilistic seismicity models

Parameters used for the two probabilistic seismicity models are given in Appendix C in the form of maps of the source zones (coordinates of the zone corners are given in Appendix D) and tables of the seismicity parameters, and in Appendix D as a full copy of the four model files used as input to the FRISK88 program.

Seismic Hazard for the Seismically less active ("stable") Part of Canada

In addition to the two probabilistic source zone models, intended to span the range of likely models for the more seismically active parts of Canada, we include for the first time the following estimate for the more stable part. About half of the Canadian landmass has too few earthquakes to define reliable seismic source zones, and on prior maps the hazard computed for these regions came only from distant external sources. However, international examples suggest that large earthquakes might occur *anywhere* in Canada (albeit rarely). To improve the reliability of the estimate of seismic hazard for the stable part of Canada we combine the earthquake activity of those stable continental shields of the globe comparable to the Canadian shield (Fenton and Adams, 1997), who reached the following conclusions:

- The maximum earthquake credible would have a magnitude of 7.0.
- Current knowledge does not permit the screening out of shield areas that could not have large earthquakes up to this size, so they should be considered as low probability events anywhere on the Canadian Shield.
- A reasonable design earthquake for the shield would be magnitude (Ms or surface wave magnitude scale) 6.0, but larger, much rarer, earthquakes can happen.
- The rate of Ms 6.0 or greater is estimated to be 0.004 p.a. per 1,000,000 square kilometres.

We compute the seismic hazard (5% damped spectral values), using eastern strong ground motion relations, at the centre of a large octagonal source zone (radius about 570 km) with the worldwide SCC per-area activity. Hazard was determined at a site in the centre so that it would not be influenced by edge effects. The Fenton-Adams selection had stringent definitions for the comparable shield areas, resulting in a conservative estimate for the seismicity of the Canadian Shield. This low seismicity rate provides a minimum seismic hazard estimate that we consider to be the lowest likely for any part of Canada not included in a source zone, and so forms an appropriate "floor". The same floor is used for some low-hazard sites west of the craton (e.g. the western Cordillera, where the activity rates are likely to be higher, but the attenuation is stronger) as an approximation.

Seismic Hazard from the Cascadia Subduction Zone

The Cascadia subduction zone has generated prehistorical great earthquakes off Vancouver Island;

from their geological record, the mean recurrence interval is about 600 years, the standard deviation of the mean is about 170 years (Adams, 1990), and the last happened about 300 years ago, likely in 1700 A.D. (Satake et al., 1996). At this point of understanding there is insufficient knowledge to estimate time-dependant seismic hazard for the next earthquake. Instead, we note that the long-term probability[1] of the next great earthquake is similar to that used for previous seismic zoning maps (10%/50 years), and new U.S. and Canadian hazard mapping projects will need to accommodate its expected ground motions. We have chosen to adopt a realistic scenario for the earthquake, and so provide a deterministic, rather than probabilistic, estimate of Cascadia earthquake ground motions. Thus we tabulate the hazard separately, but intend its combination with the probabilistic results using the robust approach.

Although on present evidence we expect the next great Cascadia subduction earthquake to have a magnitude of about 9, its expected rupture length is so long that most of this energy release will be too far from any given site to make a significant contribution to the spectral shaking level, and the hazard approximates that of a smaller (still great) earthquake near to the site. Accordingly, for the purpose of the Cascadia subduction earthquake scenario in this report, we have adopted a magnitude of 8.2, and have chosen the closest point of energy release (e.g., as depicted by Hyndman and Wang, 1993; Dragert et al. 1994) for computing distances to the various cities; this is appropriate for the Youngs et al. (1997) attenuation relation we are now using (see below). For the 10%/50 year hazard values we use the median values for the deterministic scenario, for as described above the median Cascadia subduction earthquake ground motions have about this probability.

For the 2%/50 year hazard, the median values are not appropriate, since in circa 2500 years (i.e., roughly equivalent to the 0.0004 p.a. probability level) we can expect to have 4-5 Cascadia subduction events, with a suite of shaking levels. Hence, for 5 events, there is an even chance one of the five will exceed the 75-80th percentile ground motions of the suite. This percentile is very close to the 84th, which suggests that using the "median plus 1 sigma" ground motions from our 10%/50 year calculations is appropriate for the 2%/50 hazard calculations. We have done this.

STRONG GROUND MOTION RELATIONS

The different physical properties of the crust in eastern and western Canada require the use of separate strong ground motion relations.

Eastern Canada.
For eastern Canada, a source of great uncertainty in seismic hazard estimation at the moment is the correct ground-motion relations to be used. In particular, the recordings of the 1988 Saguenay earthquake have caused the ground motion modellers to revise their prior relationships

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1 The short-term probability is lower, since we seem to be only at about the mid-point of its occurrence interval, however the variability of the mean interval makes possible recurrence intervals as short at 300 years or as long as 900 years.

to account for its unexpectedly-large short-period motions. There appears to be a consensus of experts emerging in this field (e.g., the 1994-1995 deliberations of the Senior Seismic Hazard Analysis Committee (SSHAC) of the U. S. National Academy of Sciences, see Atkinson, 1995a). Hence, we have adopted a suite of relationships[2] with their aleatory uncertainty (the base relations of Atkinson and Boore, 1995), and their epistemic uncertainty[3] (as proposed by Atkinson, 1995a), consistent with that consensus. While these appear to be representative of most of the available published relationships, recent modelling of the Saguenay ground motions by the GSC (e.g. Haddon, 1992; 1995), modelling of the second-largest well-recorded eastern earthquake, Mont-Laurier, 1990 (Haddon and Adams 1997), and both theoretical considerations of, and empirical evidence for, the source spectrum for S-waves (Haddon, 1996; see also comment by Atkinson et al. (1997) and reply by Haddon (1997)) gives us strong reservations that the absolute values the SSHAC consensus has produced are too low. We would emphasize that no matter how good our source models, the reliability of the final hazard values is highly dependent on the reliability of the extrapolations within the attenuation relations used, as observational data from large eastern earthquakes is sparse. We hope that these issues will be resolved before the preparation of our final maps for the National Building Code. In the interim, we note that the suite of relations we use gives substantially similar results, for periods of 0.5 s, to the pair being used by the USGS for the preparation of their 1996 maps which they intend to form the basis for the 1997 NEHRP provisions. One of those relationships is a single-corner-frequency model with a stress parameter of 150 bars, which gives increased ground motions at intermediate periods relative to the Atkinson-Boore two-corner-frequency model (A. Frankel, USGS, pers. comm, 1996).

The Atkinson-Boore suite of relationships was derived to fit observational data on hard-rock seismometer sites, so they need adjustment to represent the ground motions on the "firm ground"[4] reference ground condition chosen for Canada (see below under "Reference Ground Condition for Canada").

Western Canada.

For the western Canadian shallow source zones, including the subcrustal transition zones west of Vancouver Island as well as the Queen Charlotte Fault, we have adapted the ground motion relations from Boore et al. (1993, 1994 - hereafter termed 'BJF'); the same authors have published more recently (Boore et al., 1997). Our adaptation included the addition of a period-

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[2] Note that we obtained the relationship for PSA0.15 and PSA0.4 by interpolation, using log(period), of the Atkinson (1995a) Table 1 values. The PSA0.15 hazard values in particular should be used with caution because for some eastern cities and some percentiles (e.g., Fig. 9) they are less than both the PSA0.1 and PSA0.2 values (a physically unreasonable result), possibly due to one or more poorly interpolated coefficients (e.g. C4).

[3] Note that no estimate of epistemic uncertainty is available for 2 s period, so we do not give its 84th percentiles.

[4] We prefer the term "firm ground", although in foundation engineering it is common to use the term "soil" as in "California Class B soil". In that context, the term "soil" has a very different meaning than that generally understood by, say, a gardener. The "soil" classes are defined by velocity ranges; for Class B (or NEHRP Class C), this range includes very dense material and soft rock, and is not "soil" in a gardener's terms; hence our preference for "firm ground".

dependent anelastic attenuation term (using values from Atkinson, 1997) applied to distances larger than 100 km. For subcrustal source zones deeper under Puget Sound and for the Cascadia subduction zone we used Youngs et al. (1997) relationship adjusted to “firm soil”. While Crouse's 1991 relations were used in GSC Open File 3283, we believe the Youngs et al. relations are better founded, and provide our justification for the change in Appendix A3. Boore et al. (1993) differentiates between four soil classes, with most data in Class B, designated firm soil and specified as having 360 to 750 m/s average velocity in the uppermost 30 m. Our results are therefore consistent with "firm soil". As representative depths we adopted 50 km for the normal-mechanism events within the subducting slab, and 25 km for the depth of energy release of the Cascadia thrust earthquake. For the Cascadia subduction zone hazard calculation we used Youngs et al. (1997) with a magnitude of 8.2 (for reasons detailed above) and with the closest approach of the rupture zone to establish distances to the various cities.

For aleatory uncertainty for BJF we have used the smoothed standard deviations ("sigmas") about the fitted relationships, as listed by the cited authors. The epistemic uncertainty (comparable to that used for the east) on each relationship we estimate by generating a pair of parallel alternative relations, factors of two higher and lower, and having weights of 0.3 each, leaving weight 0.4 for the median relation. This epistemic uncertainty is intended to capture firstly the range of opinion on western ground motions (for example, the upper curve envelopes the Idriss (1991, 1993) relations), and secondly the possibility that there may be systematic biases in the BJF relations. For example, the stress drops of the larger western Canadian earthquakes might be either higher or lower than those used in defining the BJF relations. We recognize that the assigned epistemic uncertainties represent an arbitrary and possibly conservative choice, but prefer to err on the conservative side.

Ground Motion Parameters

In contrast to the 1985 maps, which gave values for peak ground velocity (PGV) and peak ground acceleration (PGA), we present spectral acceleration values for 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 1.0, and 2.0 second periods (denoted PSA0.1, PSA0.5, PSA2, etc) for both east and west (note epistemic uncertainty is not available for PSA2 in the east). We also give PGA values for both east and west but PGV values for just the east (a PGV ground motion relation is not available for the west).

Units.

We have decided to express the PGA and PSA values as (unitless) percentages of g. This avoids many entries of the form "0.072", with consequent duplicate characters "0." and "0.0", and also corresponds to the appropriate level of precision for the PSA and PGA values. However, this would lead to unacceptable rounding for some low values. Therefore we have kept 2 significant figures, with a maximum of one decimal digit, except for some small 2 s values for which one significant figure is appropriate. For PGV we have kept 2 significant figures but expressed the result in m/s, as for the 1985 maps, to reduce the chance of confusion with the PSA and PGA values.

REFERENCE GROUND CONDITION FOR CANADA

For the preparation of national hazard maps it is essential to present seismic hazard levels on the same ground condition for all of Canada. Such a "reference" ground condition ("RGC") is needed in order to make the 1995 hazard values firstly, numerically comparable between east and west, and secondly, roughly comparable in intent to the current (1985) hazard maps.

The BJF "Soil Class B" is our choice for the Canada-wide Reference Ground Condition, because:

a) it appears to be the closest to the soil conditions implied in 1985 NBCC and referred as 'rock or firm soil'. Class B is the softer part of the 'rock' classification earlier proposed by Joyner, Boore and co-workers, with the larger number of strong motion recordings.
b) "Soil Class B" is the reference ground condition for the main strong motion relationship we use in western Canada.
c) a choice near the mid-range between very hard and very soft ground is preferred because it minimises the effects of uncertainty in the amplification or deamplification factors for the extreme sites.
d) the Hasegawa et al. (1981) relations used in eastern Canada for the 1985 maps were established by setting their near-source levels equal to those for western Canada (i.e. on "firm ground") and using isoseismal (felt intensity) maps to constrain the distance dependence of the relations. The isoseismal maps relied on felt-intensities reported by Canadians living on average eastern site conditions that were certainly not "hard rock". Thus the Class B "firm ground" condition is, in our view, close to the ground conditions that were implied by the 1985 eastern relationships.

The hard-rock strong ground motion equation of Atkinson and Boore (1995) has been modified by Atkinson (1995a) to represent motions on ground conditions other than rock in a way similar to that of BJF's equation for the western U.S. — by the addition of a soil response parameter, c_5S, (S=0 for hard rock and S=1 for soil sites) whose coefficients, c_5, are a function of period. Atkinson (1995a) does not recommend values for her c_5 coefficients, but notes that for 'deep soil' the values in Atkinson and Boore (1995), adopted directly from Boore and Joyner (1991), might be applicable.

Approach used to compute the RGC factors given in GSC Open File 3029

For our "firm ground" reference ground condition we propose to use BJF's "B6" coefficients (as smoothed by period, see Boore et al., (1993) Table 7b and Fig. 3a, which are reproduced in Appendix E) as the seismological basis of our period-dependent values. The B6 coefficients relate BJF's California Soil Class B to the California Soil Class A, which is rock/soil with average velocity >750 m/s. Only one of the sites that contributed data to BJF's 1993 analysis was on rock with average velocity >1500 m/s. Hence the California Soil Class A is distinct from eastern Canadian hard rock seismometer sites which were the observational basis for the Atkinson-Boore eastern relations, and which have velocities of >2000 m/s.

A new "Hard Rock" class (termed 'Ao' by Martin and Dobry (1994) and adopted into the 1994 NEHRP Provisions (NEHRP, 1994), section 1.4.2, after being renamed 'A'), has been defined to have average velocity >1500 m/s, and may be appropriate for eastern hard-rock sites (e.g. Beresnev and Atkinson 1997). Martin and Dobry (1994) reported the conclusions of a 1992 workshop on earthquake site response which represented the consensus of Borcherdt, Dobry, and Seed. Their Tables 2 and 3 (reproduced in our Appendix E) show that for both 0.3 s and 1 s periods, and for all shaking intensities, motions on Class A sites are 25% higher than on Class

Ao sites. Although they specifically note that their analysis in those tables "does not address the period range between 0 and about 0.2 seconds, and thus cannot be used to amplify peak acceleration or other high frequency spectral values" we consider this caution should not apply to the A to Ao relationship as significant sources of non-linearity seem absent. Hence, we increase the B6 coefficients by the 25% factor (0.097 log units), and consider these RGC factors (Table 1) to represent the difference in amplification between the hard-rock sites for which the Atkinson-Boore relations were derived and our reference "firm ground" condition.

Appendix B, taken from GSC Open File 3283, contains details of alternative approaches that could be used to compute RGC factors. Figure 4 compares the different results, which are discussed in the Appendix. The conclusions regarding RGC Factors are:

- The Reference Ground Condition (RGC) amplifications factors in Table 1 are adequate for converting from eastern hard rock sites as used by Atkinson and Boore (1995) to "firm ground" (BJF class B soil conditions).
- Eastern hard rock is not significantly harder than was assumed by the Martin and Dobry class 'Ao' or NEHRP class 'A'.
- More complicated approaches using shear-wave velocities, as suggested by BJF 1994, produce similar amplification of hard rock strong ground motions for most periods.

Use of the RGC Factors

The Reference Ground Condition (RGC) factors in Table 1 have been used to amplify seismic hazard *spectral* values calculated from the hard-rock Atkinson-Boore relations to those to be expected for the reference ground condition. This is mathematically identical to introducing the appropriate log factors into the Atkinson-Boore strong ground motion relations (e.g. through Atkinson's 1995 soil-response parameter, S) before the hazard calculation. For consistency, a similar factor must be applied to the PGA and PGV values, but for those parameters it is necessary to assign an average period for the motions; we have chosen 0.1 s for PGA and 0.5 s for PGV, but recognize that these periods may be a function of earthquake magnitude and distance (for the 1985 NBCC maps the choice was 0.2 and 1 s.). It is important to realize that hard-rock hazard values for eastern sites can be extracted from Tables 3, 4 and 6 by dividing the tabulated values by the appropriate RGC factor from Table 1.

Not too much should be read into the 3-figure precision for the RGC factors supplied in Table 1. We considered multiplying all periods by a simple factor of two, being a crude approximation with no pretensions to either accuracy or precision, however, on balance we feel that the tabulated RGC factors better represent the period dependence. If new information on the reference ground condition arises, it can be incorporated by a revision of the RGC factors.

The effect of applying the RGC factors is to flatten the spectra of eastern sites, most particularly by the small amplification at 0.1 s. This is evident in Table 2 and Figure 5 which compare the 50th percentile 10%/50 year hazard values for Montreal for hard-rock and firm ground. There is a similar effect for the 2%/50 year spectra. Not all adjustments result in increases in ground motions - a notable feature for some Fraser Delta sites is that for high frequencies and soft soils the severity of very strong ground motions is reduced, possibly even below those on a hard rock site.

The above conclusions are independent of shaking intensity, at least to the degree that BJF's California-based B6 coefficients incorporate and do not separately identify shaking intensity. However, Martin and Dobry (1994 - see their Table 2 and 3 reproduced in our Appendix E) estimate how the amplification of strong ground motions on soft soils is relatively reduced as the severity of shaking increases. The implication is that intensity-related foundation factors, like those of Martin and Dobry (1994), may be needed to adjust our "firm ground" values to softer site conditions. This issue becomes more important as 2%/50 year values are to be used as the basis for the next building code, and these values are typically twice as large as the 10%/50 year values, with more potential for non-linear effects.

We have investigated the possible size of shaking intensity adjustments like those in Martin and Dobry's tables to our "firm-ground" site as follows. The Aa and Av values refer to acceleration values, therefore we divide our 5% damped spectral values by 2.5 as an approximate conversion. For most cities our 2%/50 year values then correspond to the column 0.1 g on line "C" (= BJF class B). For stronger shaking (e.g., Montreal short period hazard) we compare the "C" line of Martin and Dobry's Table 2 Aa=0.25 of circa 1.3 with Aa=0.1 of 1.6, suggesting a 20% deamplification of these stronger motions. For short periods at Vancouver and Victoria, Aa=0.4 gives 1.1 compared to 1.6 at Aa=0.1, and suggesting a 30% deamplification. While factors of 20-30% are significant, we consider that in an average sense they are already taken into account by BJF's B6 coefficients, and so neglect any further consideration of them at this time. Furthermore, there is an intriguing possibility that the non-linear effects observed in large California earthquakes may be more due to finite-source issues than to non-linearity in site effects (O'Connell, 1999). Such non-linear effects might be smaller for Canadian cities, since short period deaggregations for Vancouver and Montreal indicate the major contributions are from magnitude 6.4-6.5 events (Adams and Halchuk, in prep.), sources smaller than the California events.

Discussion

The proposed scheme allows the uniform representation of seismic hazard across Canada. The choice of "firm ground" (Class B soil) as the reference is appropriate, because this is the ground condition with the best observational data set (from California) and is the basis for the BJF relations we are using for western Canada. However, we emphasize we are not making any judgment as to whether Class B is a typical or even a common condition in either western or eastern Canada. Adjustments will need to be made to compensate for ground conditions different from Class B, most probably through a redefined Foundation factor, F. It is entirely possible that most sites will not have F = 1.0.

The choice of "firm ground" (Class B soil), and hence the RGC factors in Table 1, places some constraints on the Foundation factors that must be used with the hazard results. In the current (1995) National Building Code of Canada, Foundation factors of 1.0, 1.3, 1.5, and 2.0 are applied to the zonal hazard values, both east and west, dependent on the type and depth of soil as described in Table 4.1.9.C of the current code. The current code considers only amplifications of the computed hazard, and gives no credit for sites on hard rock. We consider that a consistent set of foundation factors should adjust the ground motion levels on the reference soil (irrespective of whether it is sited in the east or the west) to the various typical ground conditions. For some conditions, e.g., long period motion on thick soft soils, this will be an amplification from the computed hazard (like the current code); for short period motion on thick soils the amplification may be traded off against anelastic attenuation, reducing the motions.

Hence, our choice of "firm ground" (Class B soil) requires that considerable deamplification also be allowed (i.e., $F < 1$) to give credit for better ground conditions than Class B. To be explicit, a period-dependent F factor which is the exact reciprocal of the RGC factors in Table 1, would be required in order to recover the "hard-rock" ground motions, which should be the basis for design levels if a building's foundation is set on, or blasted into, hard rock. Although these "exact" foundation factors are the correct ones, a simplified set may be more appropriate for code purposes. The same deamplification may occur in both eastern and western Canada, because some west coast rock sites have rock velocities as high as many eastern hard rock sites; though other rock sites may be equivalent to California class A rock.

A further complication is that actual soil sites differ in both thickness and average velocity from the "firm ground" (Class B soil) condition. Class B was established for California, where most soils would be considered "deep", say 60 m thick, in contrast to much of eastern Canada where many firm soils are "thin". A soil column that is similar to the Class B soil, but only half as thick, will give both a different amount of amplification, but also a different distribution of amplification with period. Another issue not fully addressed by the trend in the U.S. to use average velocity of the soil/rock column in the top 30 m, is the treatment of thin, very low velocity sediment over rock, which could have the same average 30-m velocity as a 30-m firm soil but very different amplifications.

It has been suggested that the typical eastern site has thinner and firmer soil than Class B; this will tend to cause less amplification at long periods, but more at short periods (because of competing effects involving thickness and the Kappa factor, i.e. anelastic attenuation). Hard data is sparse for eastern Canada, but five seismometer sites in southern Ontario (founded on firm till, but underlain by an unknown thickness of sediment of unknown properties) have considerable short-period amplification (G. Atkinson, pers. comm., 1995), exceeding a factor of five at 0.1 s for station WEO (Atkinson, 1989). Whether such sites would experience reduced amplification for larger earthquakes is unknown.

RESULTS

Tables 3 and 4 give 2% and 10% in 50 year probabilistic hazard values for selected Canadian cities, itemizing separately the values for the H and R models and the 50th and 84th percentiles. Table 5 presents the stable shield "floor" values[5], Table 6 is a summary of the Cascadia subduction earthquake scenario hazard, and Table 7 represent a 1-page summary of the robust hazard from Tables 3, 5 and 6 for the 2%/50 year probability level.

[5] Note: these values superceed those in Adams et al., 1999

DISCUSSION AND CONCLUSIONS

Combining diverse hazard estimates using the 'robust' approach

It is important to realize that each of the entries labelled 'H' or 'R' in the tables represents the result of a complete probabilistic hazard calculation. Combining such diverse models within a probabilistic framework inevitably requires that one or other alternative models be down-weighted, thus reducing the protection it would otherwise provide.

Adams et al. (1994; 1995c) suggested a 'quasi-probabilistic' alternative method that they termed "robust". We first compute the probabilistic hazard for a 100% **H** and for a 100% **R** model using the same grid of points, and then choose the higher value for each grid point to be contoured for the "robust" map. The mapped "robust" estimates are "probabilistic" at any one place, in that for each site and every ground motion parameter being computed there is an identifiable probabilistic hazard calculation made using a particular source-zone model. Hence for design purposes (for a building or a city) the map provides a suitable probabilistic hazard value, though from a regional perspective the map as a whole is not probabilistic, because the model used may differ from site to site, or indeed from ground motion period to period at a particular site. In a similar way, the floor values from the stable craton probabilistic calculation can be incorporated with the source zone hazard results.

The chief advantage of the "robust" approach is that it preserves protection in areas of high seismicity but also provides increased protection in currently-aseismic areas that are geologically-likely to have future large earthquakes, for example the St. Lawrence valley near Trois-Rivières. A further advantage is that the approach is computationally simple, and it is easy to explain what was done. Finally, the method allows a simple combination of deterministic and probabilistic hazard where this is desired. For example, the values for the seismic hazard from the Cascadia subduction earthquake scenario in Table 6 are intended to be incorporated into the national hazard maps by the 'robust' approach; that is, where the Cascadia ground motions are larger than the probabilistic calculation, the Cascadia values would be adopted. The same applies to the stable craton "floor" values in Table 5, i.e., if the floor hazard is higher than that computed from the seismic source models **H** or **R** (i.e. probabilistic hazard from distant seismic sources) we adopt the floor value instead. We note that use of these floor values eliminates the lowest contours from many of the hazard maps we have previously produced.

Choice of Confidence Level

We provide values for two confidence levels, the 50th percentile and the 84th percentile; the former is the median, and the latter includes a measure of epistemic uncertainty[6]. Either might be used for engineering design. The median is often chosen because it is a robust parameter and can be expected to remain stable as the range of scientific opinion changes, while the 84th

[6]The 84th percentile is often chosen, because for a normal (or lognormal) distribution it corresponds the median plus one standard deviation. The standard deviation is less meaningful in our case, since the distributions of ground motions can be quite asymmetrical, due to the fact that the epistemic distribution is or can be quite asymmetric, and may be far from lognormal. Nevertheless, the use of the 84th percentile does include a measure of the epistemic uncertainty which we wish to include.

percentile must be expected to fluctuate in future (hopefully decreasing over the long term) as improved knowledge about epistemic uncertainty is incorporated into the analysis.

Naumoski and Heidebrecht (1995) proposed that the 84th percentile of the 10%/50 year values be used to determine seismic loading because this ensures that there is little likelihood the design value will be exceeded, so providing an appropriate degree of engineering conservatism consistent with general engineering practice. Explicitly, that proposal says that instead of accepting a 50% chance that the 0.0021 p.a. ground motion will be exceeded, it would be better to choose a higher ground motion level and then be 84% sure that this higher value will not be exceeded. It will be noted that the 84^{th} percentile of the 10%/50 year uniform hazard spectra is, coincidentally, very similar to the median (50^{th} percentile) of the 2%/50 year results (see e.g. Figures 6 to 27, the chief exception is for high frequencies in the east). Thus a design based on the median 2%/50 values effectively accommodates Naumoski and Heidebrecht's proposal.

Uniform Hazard Spectra

Spectral plots (Figures 6-27) show the results from Tables 3-6 as Uniform Hazard Spectra (UHS). Each figure shows, for both the 10%/50 year and 2%/50 year probability levels, the median (50th percentile) and 84th percentile UHS determined by the robust approach; i.e., the values plotted for each period are the higher of the H or R model values. Hence adjacent values may have been taken from different models. Note that it is inappropriate to display PGA values on these plots (even though PGA is sometimes (arbitrarily) plotted at 0.03 s or 0.01 s), because its associated period differs from place to place and is generally not known.

Non-Newmark-Hall amplification

The previous code used scaled Newmark-Hall spectra (Newmark and Hall, 1969; 1982). These spectra were derived by averaging (or enveloping) the few then available spectra from magnitude 6-7 earthquakes in the 20-50 km range. The spectral shape was specified by certain corner frequencies and fixed amplification factors relative to peak ground motion. If the dominant hazard at the desired probability level comes from such earthquakes and distances in a similar tectonic environment, this spectrum is appropriate. For many sites in Canada, short period hazard comes from smaller magnitude events at near distances; longer period hazard from larger earthquakes at greater distances. This was recognized by the last code edition by giving PGA and PGV values at the same hazard level, necessarily resulting in a variable corner period, i.e. variable spectral shape. Similarly, the spectral acceleration relations now allow construction of uniform hazard spectra for given sites (e.g., Figs 6-27) which have variable shapes and amplification factors different from the deterministically-derived Newmark-Hall spectrum.

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TABLES

FIGURE CAPTIONS

Figure 1. Earthquake source zone maps of Canada showing the zones that form the **H** (top) and **R** (bottom) models for earthquake distribution. Zones referred to in the text are shaded and labelled on the bottom map; corresponding **H**-model zones are shaded on the top map.

Figure 2. Sample magnitude-recurrence data and curves, for Charlevoix and the Niagara-Attica Trend (NAT) zones. The cumulative rates of earthquakes are represented by solid circles with stochastic error bounds and the best-fit curve (bold) are flanked by upper and lower "error" curves that are more widely separated for the poorly-constrained NAT dataset. All curves are asymptotic to assumed upper-bound magnitudes.

Figure 3. Magnitude-recurrence data and curves for CASR, the shallow crustal source for the Strait of Georgia - Puget Sound region. The maximum likelihood fit including the small magnitude earthquakes (lower curve) passes through the point (0.002, 7.0), considerably below the historical rate of $M>6.8$ earthquakes. The maximum likelihood fit to only $M>4.75$ earthquakes (upper curve) matches the historical rate of larger earthquakes much better. Both curves are asymptotic to assumed upper-bound magnitudes.

Figure 4. RGC factors as a function of period, as derived by the three methods described in the text and shown in Appendix B. The "Table 1" factors are the preferred ones.

Figure 5. Seismic hazard for Montreal depicted as Uniform Hazard Spectra on various ground conditions. These 50th percentile 10%/50 year UHS from the **R** model are derived from values given in Table 4 for hard-rock and soil Class B using the RGC factors; a baseline derived from the hard-rock values using a uniform amplification of a factor of two is shown for comparison.

Figures 6-27 show the 0.0021 and 0.000404 per annum ground motion "firm ground" results as Uniform Hazard Spectra for the named city. For each probability, the 50th percentile (solid line) and 84th percentile (dotted line) UHS are derived by the robust method from the **H** and **R** model values given in Tables 3 or 4. For southwestern Canadian cities, two additional curves (dashed lines) are shown. These are the 50th and 84th percentile spectra for the scenario M8.2 Cascadia event, as given in Table 6.

Figure 6. St. John's	Figure 7. Halifax	Figure 8. Moncton
Figure 9. Fredericton	Figure 10. La Malbaie	Figure 11. Quebec
Figure 12. Trois-Rivières	Figure 13. Montreal	Figure 14. Ottawa
Figure 15. Niagara Falls	Figure 16. Toronto	Figure 17. Windsor
Figure 18. Calgary	Figure 19. Kelowna	Figure 20. Kamloops
Figure 21. Prince George	Figure 22. Vancouver	Figure 23. Victoria
Figure 24. Tofino	Figure 25. Prince Rupert	
Figure 26. Queen Charlotte City	Figure 27. Inuvik	

Table 1

Proposed Reference Ground Condition factors

Period (s)	B6	A-to-Ao	C_5	RGC factor
	.........$\log_{10}$ units.........			
0.1	0.046	0.097	0.143	1.39
0.15	0.140	0.097	0.237	1.73
0.2	0.190	0.097	0.287	1.94
0.3	0.239	0.097	0.336	2.17
0.4	0.264	0.097	0.361	2.30
0.5	0.279	0.097	0.376	2.38
1.0	0.314	0.097	0.411	2.58
2.0	0.360	0.097	0.457	2.86
PGA	0.046	0.097	0.143	1.39
PGV	0.279	0.097	0.376	2.38

Notes:

1. This table reproduces Table 1 of GSC Open File 3283 by the addition of values for the 2.0 s period.
2. Column B6 is taken from Boore-Joyner-Fumal (1993) Table 7b.
3. The A-to-Ao conversion is +25% from Martin and Dobry (1994), Tables 2 and 3 (site class A = 1.0, site class Ao = 0.8 for all shaking intensities and both Fa and Fv periods).
4. Column C_5 contains the proposed coefficients (in $\log_{10}$ units) to be used for Class B soil with Atkinson's (1995a) S parameter.
5. The RGC (Reference Ground Condition) factor represents the C_5 values as a multiplicative factor, and is intended to modify eastern hard rock hazard values to those expected on the reference ground condition of "firm ground".
6. RGC factors for PGA and PGV were assigned by associating them with periods of 0.1 s and 0.5 s., respectively.

Table 2

Effects of Reference Ground Condition factors for a sample eastern site (Montreal)

Period (s)	Hard rock	RGC (Table 1)	Firm Ground
0.1	22	1.39	31
0.15	17	1.73	30
0.2	15	1.94	29
0.3	9.5	2.17	21
0.4	6.9	2.30	16
0.5	5.4	2.38	13
1.0	2.1	2.58	5.3
2.0	0.6	2.86	1.7

Notes:

1. Entries in the table represent the 50th percentile values of the 0.0021 p.a. seismic hazard (5% damped PSA values in %g) for the **R** model.
2. The "Hard rock" values are those computed using the Atkinson and Boore (1995) hard-rock ground motion relations; "firm ground" is the amplification of the hard rock values by the RGC factors given in Table 1).
3. The hazard values are rounded.

Table 3

2%/50 year probability Probabilistic Seismic Hazard Estimates for Selected Cities[1]

Eastern Cities - Spectral values prob 2%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
St. John's (47.6, -52.7)						
PSA 0.1 sec	12	17	13	20	13	20
PSA 0.15 sec	15	24	15	27	15	27
PSA 0.2 sec	15	27	18	31	18	31
PSA 0.3 sec	13	27	16	33	16	33
PSA 0.4 sec	10	25	13	31	13	31
PSA 0.5 sec	9.0	23	11	29	11	29
PSA 1.0 sec	4.5	13	6.0	16	6.0	16
PSA 2.0 sec	1.3	-[2]	1.6	-	1.6	-
PGA	8.4	12	9.0	13	9.0	13
PGV	0.048	0.12	0.057	0.14	0.057	0.14
Halifax (44.6, -63.6)						
PSA 0.1 sec	13	18	20	29	20	29
PSA 0.15 sec	15	26	22	35	22	35
PSA 0.2 sec	16	29	23	41	23	41
PSA 0.3 sec	14	29	19	40	19	40
PSA 0.4 sec	11	28	15	38	15	38
PSA 0.5 sec	9.9	26	13	34	13	34
PSA 1.0 sec	5.1	14	7.0	19	7.0	19
PSA 2.0 sec	1.5	-	1.9	-	1.9	-
PGA	8.5	12	12	19	12	19
PGV	0.052	0.14	0.071	0.18	0.071	0.18
Moncton (46.1, -64.8)						
PSA 0.1 sec	31	43	24	36	31	43
PSA 0.15 sec	29	50	24	45	29	50
PSA 0.2 sec	30	52	28	49	30	52
PSA 0.3 sec	23	44	22	45	23	45
PSA 0.4 sec	19	46	17	41	19	46
PSA 0.5 sec	16	42	14	37	16	42
PSA 1.0 sec	6.8	22	6.5	20	6.8	22
PSA 2.0 sec	2.1	-	2.0	-	2.1	-
PGA	21	29	16	25	21	29
PGV	0.095	0.23	0.081	0.21	0.095	0.23
Fredericton (45.9, -66.6)						
PSA 0.1 sec	33	47	39	57	39	57
PSA 0.15 sec	32	58	36	66	36	66
PSA 0.2 sec	35	62	39	69	39	69
PSA 0.3 sec	27	52	29	56	29	56
PSA 0.4 sec	23	52	24	58	24	58
PSA 0.5 sec	19	48	20	52	20	52
PSA 1.0 sec	8.6	26	8.1	27	8.6	27
PSA 2.0 sec	2.7	-	2.6	-	2.7	-
PGA	23	31	27	38	27	38
PGV	0.11	0.27	0.12	0.29	0.12	0.29

Eastern Cities - Spectral values prob 2%/50 years

Spectral	H Model		R Model		Robust	
Parameter	50%ile	84%ile	50%ile	84%ile	50%ile	84%ile
La Malbaie (47.6 -70.1)						
PSA 0.1 sec	190	330	64	93	190	330
PSA 0.15 sec	220	350	68	100	220	350
PSA 0.2 sec	230	380	65	110	230	380
PSA 0.3 sec	170	360	48	99	170	360
PSA 0.4 sec	140	350	36	87	140	350
PSA 0.5 sec	120	310	32	78	120	310
PSA 1.0 sec	59	180	13	41	59	180
PSA 2.0 sec	19	-	4.3	-	19	-
PGA	110	200	41	62	110	200
PGV	0.62	1.55	0.17	0.45	0.62	1.55
Quebec (46.8, -71.2)						
PSA 0.1 sec	46	62	58	85	58	85
PSA 0.15 sec	48	75	61	93	61	93
PSA 0.2 sec	52	89	59	100	59	100
PSA 0.3 sec	41	88	43	88	43	88
PSA 0.4 sec	34	81	33	79	34	81
PSA 0.5 sec	29	75	29	71	29	75
PSA 1.0 sec	14	44	11	37	14	44
PSA 2.0 sec	4.8	-	4.0	-	4.8	-
PGA	28	39	37	57	37	57
PGV	0.14	0.39	0.16	0.41	0.16	0.41
Trois-Rivieres (46.3, -72.5)						
PSA 0.1 sec	31	47	63	92	63	92
PSA 0.15 sec	31	57	67	100	67	100
PSA 0.2 sec	35	62	64	110	64	110
PSA 0.3 sec	28	57	47	96	47	96
PSA 0.4 sec	23	56	35	85	35	85
PSA 0.5 sec	20	52	31	77	31	77
PSA 1.0 sec	10	29	12	40	12	40
PSA 2.0 sec	3.2	-	4.3	-	4.3	-
PGA	20	32	40	61	40	61
PGV	0.11	0.27	0.17	0.44	0.17	0.44
Montreal (45.5, -73.6)						
PSA 0.1 sec	57	89	68	96	68	96
PSA 0.15 sec	58	97	71	110	71	110
PSA 0.2 sec	58	100	69	120	69	120
PSA 0.3 sec	43	86	50	110	50	110
PSA 0.4 sec	35	86	39	95	39	95
PSA 0.5 sec	29	71	34	83	34	83
PSA 1.0 sec	13	38	14	44	14	44
PSA 2.0 sec	3.8	-	4.8	-	4.8	-
PGA	37	59	43	63	43	63
PGV	0.17	0.43	0.18	0.48	0.18	0.48

Eastern Cities - Spectral values prob 2%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Ottawa (45.4, -75.7)						
PSA 0.1 sec	40	61	66	95	66	95
PSA 0.15 sec	43	78	69	110	69	110
PSA 0.2 sec	45	85	67	110	67	110
PSA 0.3 sec	34	73	48	100	48	100
PSA 0.4 sec	28	65	38	90	38	90
PSA 0.5 sec	23	58	32	80	32	80
PSA 1.0 sec	10	31	14	42	14	42
PSA 2.0 sec	3.1	-	4.5	-	4.5	-
PGA	25	40	42	63	42	63
PGV	0.13	0.33	0.18	0.46	0.18	0.46
Niagara Falls (43.1, 79.1)						
PSA 0.1 sec	46	72	19	31	46	72
PSA 0.15 sec	41	78	20	36	41	78
PSA 0.2 sec	41	93	21	38	41	93
PSA 0.3 sec	31	77	16	35	31	77
PSA 0.4 sec	25	62	14	31	25	62
PSA 0.5 sec	20	52	11	28	20	52
PSA 1.0 sec	7.1	25	5.5	15	7.1	25
PSA 2.0 sec	2.1	-	1.5	-	2.1	-
PGA	30	48	14	22	30	48
PGV	0.13	0.34	0.067	0.17	0.13	0.34
Toronto (43.7, -79.4)						
PSA 0.1 sec	27	42	17	27	27	42
PSA 0.15 sec	28	53	17	32	28	53
PSA 0.2 sec	28	55	20	34	28	55
PSA 0.3 sec	22	47	15	32	22	47
PSA 0.4 sec	16	38	13	29	16	38
PSA 0.5 sec	13	33	11	27	13	33
PSA 1.0 sec	4.9	17	5.4	14	5.4	17
PSA 2.0 sec	1.5	-	1.4	-	1.5	-
PGA	20	28	12	19	20	28
PGV	0.081	0.21	0.062	0.16	0.081	0.21
Windsor (42.3, -83.0)						
PSA 0.1 sec	8.8	14	16	26	16	26
PSA 0.15 sec	9.4	20	16	30	16	30
PSA 0.2 sec	12	21	17	32	17	32
PSA 0.3 sec	9.6	22	13	27	13	27
PSA 0.4 sec	7.9	19	10	23	10	23
PSA 0.5 sec	6.5	17	8.3	21	8.3	21
PSA 1.0 sec	2.4	8.4	3.9	11	3.9	11
PSA 2.0 sec	0.8	-	1.1	-	1.1	-
PGA	5.9	8.9	12	19	12	19
PGV	0.038	0.098	0.055	0.14	0.055	0.14

Western Cities - Spectral values prob 2%/50 years

Spectral Parameter	H model 50%ile	H model 84%ile	R model 50%ile	R model 84%ile	robust 50%ile	robust 84%ile
Calgary (51.0, -114.0)						
PSA 0.1 sec	10	18	6.1	12	10	18
PSA 0.15 sec	14	27	8.9	18	14	27
PSA 0.2 sec	15	29	9.7	19	15	29
PSA 0.3 sec	13	25	8.8	18	13	25
PSA 0.4 sec	10	20	7.4	15	10	20
PSA 0.5 sec	8.4	17	6.2	12	8.4	17
PSA 1.0 sec	4.1	8.0	3.2	6.4	4.1	8.0
PSA 2.0 sec	2.3	4.6	1.9	3.7	2.3	4.6
PGA	8.8	18	5.5	11	8.8	18
Kelowna (49.9, -119.4)						
PSA 0.1 sec	18	36	12	24	18	36
PSA 0.15 sec	26	51	17	34	26	51
PSA 0.2 sec	27	55	19	37	27	55
PSA 0.3 sec	24	49	17	35	24	49
PSA 0.4 sec	20	40	16	31	20	40
PSA 0.5 sec	17	34	14	28	17	34
PSA 1.0 sec	8.6	17	8.9	18	8.9	18
PSA 2.0 sec	4.8	9.5	5.3	11	5.3	11
PGA	14	27	9.8	20	14	27
Kamloops (50.7, -120.3)						
PSA 0.1 sec	18	37	13	26	18	37
PSA 0.15 sec	26	52	19	37	26	52
PSA 0.2 sec	28	55	20	40	28	55
PSA 0.3 sec	25	49	19	39	25	49
PSA 0.4 sec	20	40	17	35	20	40
PSA 0.5 sec	17	34	16	31	17	34
PSA 1.0 sec	8.5	17	10	20	10	20
PSA 2.0 sec	4.8	9.5	6.0	12	6.0	12
PGA	14	27	11	21	14	27
Prince George (53.9, -122.7)						
PSA 0.1 sec	8.3	17	5.9	12	8.3	17
PSA 0.15 sec	12	24	8.6	17	12	24
PSA 0.2 sec	13	26	9.3	19	13	26
PSA 0.3 sec	12	23	8.5	17	12	23
PSA 0.4 sec	9.6	19	7.2	14	9.6	19
PSA 0.5 sec	8.0	16	6.2	12	8.0	16
PSA 1.0 sec	4.0	8.0	3.8	7.6	4.0	8.0
PSA 2.0 sec	2.4	4.8	2.5	5.0	2.5	5.0
PGA	7.1	14	5.4	11	7.1	14
Vancouver (49.2, -123.2)						
PSA 0.1 sec	83	170	83	170	83	170
PSA 0.15 sec	97	190	100	200	100	200
PSA 0.2 sec	96	190	100	200	100	200
PSA 0.3 sec	82	160	87	170	87	170
PSA 0.4 sec	72	140	76	150	76	150
PSA 0.5 sec	64	130	67	130	67	130
PSA 1.0 sec	30	60	34	69	34	69
PSA 2.0 sec	13	27	18	35	18	35
PGA	48	96	47	95	48	96

Western Cities - Spectral values prob 2%/50 years

Spectral Parameter	H model 50%ile	H model 84%ile	R model 50%ile	R model 84%ile	robust 50%ile	robust 84%ile
Victoria (48.5, -123.3)						
PSA 0.1 sec	110	220	98	200	110	220
PSA 0.15 sec	120	250	120	230	120	250
PSA 0.2 sec	120	250	110	230	120	250
PSA 0.3 sec	110	210	99	200	110	210
PSA 0.4 sec	92	180	85	170	92	180
PSA 0.5 sec	83	170	76	150	83	170
PSA 1.0 sec	38	77	38	75	38	77
PSA 2.0 sec	17	34	19	37	19	37
PGA	62	120	55	110	62	120
Tofino (49.1, -125.9)						
PSA 0.1 sec	22	44	43	86	43	86
PSA 0.15 sec	31	61	60	120	60	120
PSA 0.2 sec	32	65	63	130	63	130
PSA 0.3 sec	29	59	57	110	57	110
PSA 0.4 sec	25	50	48	97	48	97
PSA 0.5 sec	22	44	42	83	42	83
PSA 1.0 sec	12	24	24	48	24	48
PSA 2.0 sec	6.9	14	13	26	13	26
PGA	16	32	26	53	26	53
Prince Rupert (54.3, -130.4)						
PSA 0.1 sec	13	25	24	48	24	48
PSA 0.15 sec	18	36	34	67	34	67
PSA 0.2 sec	19	39	36	72	36	72
PSA 0.3 sec	18	36	33	65	33	65
PSA 0.4 sec	17	33	28	56	28	56
PSA 0.5 sec	16	32	24	48	24	48
PSA 1.0 sec	13	26	16	32	16	32
PSA 2.0 sec	7.8	16	9.3	19	9.3	19
PGA	10	21	17	34	17	34
Queen Charlotte City (53.3, -132.0)						
PSA 0.1 sec	42	83	43	86	43	86
PSA 0.15 sec	57	110	59	120	59	120
PSA 0.2 sec	63	130	65	130	65	130
PSA 0.3 sec	63	130	66	130	66	130
PSA 0.4 sec	63	120	64	130	64	130
PSA 0.5 sec	61	120	62	120	62	120
PSA 1.0 sec	45	91	50	100	50	100
PSA 2.0 sec	25	49	26	52	26	52
PGA	34	68	35	70	35	70
Inuvik (68.4, -133.5)						
PSA 0.1 sec	6.1	12	5.1	10	6.1	12
PSA 0.15 sec	9.1	18	7.8	16	9.1	18
PSA 0.2 sec	10	20	8.7	17	10	20
PSA 0.3 sec	9.2	18	8.4	17	9.2	18
PSA 0.4 sec	7.8	15	7.4	15	7.8	15
PSA 0.5 sec	6.7	13	6.4	13	6.7	13
PSA 1.0 sec	3.7	7.4	3.9	7.8	3.9	7.8
PSA 2.0 sec	2.3	4.6	2.5	5.0	2.5	5.0
PGA	6.0	12	5.2	10	6.0	12

Notes.
All values are given for a probability of 0.000404 p.a. (2% in 50 years) on firm ground.
[1]Spectral (5% damped) and peak acceleration values are in %g, peak velocity in m/s.
[2]PSA2.0 s epistemic uncertainty to provide the 84th percentile is not available.

Table 4

10%/50 year probability Probabilistic Seismic Hazard Estimates for Selected Cities[1]

Eastern Cities - Spectral values prob 10%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
St. John's (47.6 -52.7)						
PSA 0.1 sec	4.5	6.1	5.9	8.8	5.9	8.8
PSA 0.15 sec	5.9	9.4	7.2	12	7.2	12
PSA 0.2 sec	6.4	11	8.6	15	8.6	15
PSA 0.3 sec	5.7	12	7.8	16	7.8	16
PSA 0.4 sec	4.5	11	6.3	15	6.3	15
PSA 0.5 sec	3.7	9.7	5.4	14	5.4	14
PSA 1.0 sec	1.8	4.9	2.8	7.4	2.8	7.4
PSA 2.0 sec	0.5	-[2]	0.8	-	0.8	-
PGA	3.0	4.0	3.6	5.5	3.6	5.5
PGV	0.021	0.055	0.029	0.076	0.029	0.076
Halifax (44.6 -63.6)						
PSA 0.1 sec	4.7	6.5	9.2	13	9.2	13
PSA 0.15 sec	6.1	11	9.9	16	9.9	16
PSA 0.2 sec	7.3	13	11	19	11	19
PSA 0.3 sec	6.9	15	9.2	19	9.2	19
PSA 0.4 sec	5.6	14	7.3	18	7.3	18
PSA 0.5 sec	4.9	13	6.2	16	6.2	16
PSA 1.0 sec	2.2	6.8	3.0	8.4	3.0	8.4
PSA 2.0 sec	0.7	-	0.9	-	0.9	-
PGA	3.2	4.3	5.7	8.6	5.7	8.6
PGV	0.026	0.069	0.033	0.088	0.033	0.088
Moncton (46.1 -64.8)						
PSA 0.1 sec	10	15	9.8	14	10	15
PSA 0.15 sec	10	20	9.9	20	10	20
PSA 0.2 sec	12	22	12	22	12	22
PSA 0.3 sec	10	20	10	21	10	21
PSA 0.4 sec	8.3	19	8.0	19	8.3	19
PSA 0.5 sec	6.9	18	6.8	18	6.9	18
PSA 1.0 sec	2.9	9.3	3.0	9.0	3.0	9.3
PSA 2.0 sec	0.9	-	0.9	-	0.9	-
PGA	7.2	11	6.8	10	7.2	11
PGV	0.040	0.10	0.038	0.10	0.040	0.10
Fredericton (45.9 -66.6)						
PSA 0.1 sec	13	19	14	21	14	21
PSA 0.15 sec	13	26	13	28	13	28
PSA 0.2 sec	16	29	17	29	17	29
PSA 0.3 sec	13	27	13	25	13	27
PSA 0.4 sec	10	25	10	25	10	25
PSA 0.5 sec	8.6	22	8.6	22	8.6	22
PSA 1.0 sec	3.7	12	3.7	11	3.7	12
PSA 2.0 sec	1.1	-	1.1	-	1.1	-
PGA	8.9	13	9.4	14	9.4	14
PGV	0.048	0.13	0.050	0.13	0.050	0.13

Eastern Cities - Spectral values prob 10%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
La Malbaie (47.6 -70.1)						
PSA 0.1 sec	94	150	28	38	94	150
PSA 0.15 sec	110	170	27	41	110	170
PSA 0.2 sec	100	170	27	44	100	170
PSA 0.3 sec	71	150	19	38	71	150
PSA 0.4 sec	57	130	14	34	57	130
PSA 0.5 sec	48	120	11	29	48	120
PSA 1.0 sec	20	60	4.4	14	20	60
PSA 2.0 sec	6.1	-	1.4	-	6.1	-
PGA	59	97	19	25	59	97
PGV	0.28	0.68	0.071	0.18	0.28	0.68
Quebec (46.8 -71.2)						
PSA 0.1 sec	22	31	24	33	24	33
PSA 0.15 sec	23	36	24	36	24	36
PSA 0.2 sec	24	41	24	39	24	41
PSA 0.3 sec	19	39	17	35	19	39
PSA 0.4 sec	15	37	13	32	15	37
PSA 0.5 sec	13	33	11	27	13	33
PSA 1.0 sec	5.7	17	4.2	14	5.7	17
PSA 2.0 sec	1.7	-	1.4	-	1.7	-
PGA	14	20	16	22	16	22
PGV	0.071	0.18	0.067	0.17	0.071	0.17
Trois-Rivieres (46.3 -72.5)						
PSA 0.1 sec	13	19	27	36	27	36
PSA 0.15 sec	14	25	26	39	26	39
PSA 0.2 sec	17	29	26	43	26	43
PSA 0.3 sec	14	29	18	37	18	37
PSA 0.4 sec	11	26	14	33	14	33
PSA 0.5 sec	9.2	24	11	29	11	29
PSA 1.0 sec	4.3	12	4.5	14	4.5	14
PSA 2.0 sec	1.3	-	1.5	-	1.5	-
PGA	8.7	13	18	25	18	25
PGV	0.050	0.13	0.071	0.18	0.071	0.18
Montreal (45.5 -73.6)						
PSA 0.1 sec	22	35	30	41	30	41
PSA 0.15 sec	24	39	29	45	29	45
PSA 0.2 sec	24	43	29	49	29	49
PSA 0.3 sec	18	36	21	42	21	42
PSA 0.4 sec	14	33	15	37	15	37
PSA 0.5 sec	11	29	13	32	13	32
PSA 1.0 sec	4.8	14	5.2	16	5.2	16
PSA 2.0 sec	1.4	-	1.6	-	1.6	-
PGA	16	25	20	27	20	27
PGV	0.071	0.18	0.079	0.20	0.079	0.20

Eastern Cities - Spectral values prob 10%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Ottawa (45.4 -75.7)						
PSA 0.1 sec	18	27	29	39	29	39
PSA 0.15 sec	18	35	29	43	29	43
PSA 0.2 sec	21	37	28	48	28	48
PSA 0.3 sec	15	32	20	40	20	40
PSA 0.4 sec	12	28	15	36	15	36
PSA 0.5 sec	9.6	24	12	31	12	31
PSA 1.0 sec	4.3	12	5.0	15	5.0	15
PSA 2.0 sec	1.2	-	1.5	-	1.5	-
PGA	12	19	20	27	20	27
PGV	0.057	0.14	0.076	0.19	0.076	0.19
Niagara Falls (43.1 -79.1)						
PSA 0.1 sec	18	26	7.7	11	18	26
PSA 0.15 sec	16	32	7.7	14	16	32
PSA 0.2 sec	16	31	9.0	16	16	31
PSA 0.3 sec	11	25	7.3	16	11	25
PSA 0.4 sec	8.4	21	5.7	14	8.4	21
PSA 0.5 sec	6.5	17	4.8	12	6.5	17
PSA 1.0 sec	2.7	8.0	2.2	6.3	2.7	8.0
PSA 2.0 sec	0.8	-	0.6	-	0.8	-
PGA	12	19	5.2	8.2	12	19
PGV	0.045	0.12	0.029	0.076	0.045	0.12
Toronto (43.7 -79.4)						
PSA 0.1 sec	11	16	6.2	9.5	11	16
PSA 0.15 sec	9.7	20	6.8	13	9.7	20
PSA 0.2 sec	11	21	8.5	15	11	21
PSA 0.3 sec	8.3	18	7.0	15	8.3	18
PSA 0.4 sec	6.3	15	5.6	13	6.3	15
PSA 0.5 sec	5.0	13	4.7	12	5.0	13
PSA 1.0 sec	1.8	6.3	2.2	6.2	2.2	6.3
PSA 2.0 sec	0.6	-	0.6	-	0.6	-
PGA	7.9	11	4.5	6.6	7.9	11
PGV	0.033	0.086	0.029	0.074	0.033	0.086
Windsor (42.3 -83.0)						
PSA 0.1 sec	4.1	6.1	5.8	8.7	5.8	8.7
PSA 0.15 sec	4.4	9.3	5.8	11	5.8	11
PSA 0.2 sec	5.9	10	6.6	12	6.6	12
PSA 0.3 sec	4.6	9.6	5.1	11	5.1	11
PSA 0.4 sec	3.5	8.6	4.0	9.5	4.0	9.5
PSA 0.5 sec	2.8	7.4	3.3	8.5	3.3	8.5
PSA 1.0 sec	1.0	3.5	1.3	4.2	1.3	4.2
PSA 2.0 sec	0.3	-	0.4	-	0.4	-
PGA	2.8	4.0	4.0	6.3	4.0	6.3
PGV	0.019	0.048	0.021	0.055	0.021	0.055

Western Cities - Spectral values prob 10%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Calgary (51.0 -114.0)						
PSA 0.1 sec	4.2	8.3	2.9	5.8	4.2	8.3
PSA 0.15 sec	6.3	12	4.4	8.7	6.3	12
PSA 0.2 sec	6.8	14	4.8	9.6	6.8	14
PSA 0.3 sec	6.1	12	4.4	8.7	6.1	12
PSA 0.4 sec	5.0	9.9	3.6	7.3	5.0	9.9
PSA 0.5 sec	4.1	8.1	3.1	6.1	4.1	8.1
PSA 1.0 sec	2.0	4.0	1.6	3.1	2.0	4.0
PSA 2.0 sec	1.1	2.3	0.9	1.8	1.1	2.3
PGA	4.0	7.8	2.9	5.8	4.0	7.8
Kelowna (49.9 -119.4)						
PSA 0.1 sec	8.9	18	6.4	13	8.9	18
PSA 0.15 sec	13	25	9.1	18	13	25
PSA 0.2 sec	13	27	10	20	13	27
PSA 0.3 sec	12	24	9.6	19	12	24
PSA 0.4 sec	10	20	8.6	17	10	20
PSA 0.5 sec	8.5	17	7.8	16	8.5	17
PSA 1.0 sec	4.3	8.5	4.9	9.7	4.9	9.7
PSA 2.0 sec	2.4	4.7	2.9	5.8	2.9	5.8
PGA	7.1	14	5.3	11	7.1	14
Kamloops (50.7 -120.3)						
PSA 0.1 sec	8.8	18	7.2	14	8.8	18
PSA 0.15 sec	12	25	10	20	12	25
PSA 0.2 sec	13	27	11	22	13	27
PSA 0.3 sec	12	24	11	21	12	24
PSA 0.4 sec	9.9	20	9.6	19	9.9	20
PSA 0.5 sec	8.4	17	8.7	17	8.7	17
PSA 1.0 sec	4.2	8.4	5.4	11	5.4	11
PSA 2.0 sec	2.3	4.6	3.2	6.4	3.2	6.4
PGA	7.1	14	5.9	12	7.1	14
Prince George (53.9 -122.7)						
PSA 0.1 sec	3.5	6.9	2.7	5.4	3.5	6.9
PSA 0.15 sec	5.2	10	4.2	8.3	5.2	10
PSA 0.2 sec	5.7	11	4.6	9.2	5.7	11
PSA 0.3 sec	5.1	10	4.3	8.6	5.1	10
PSA 0.4 sec	4.3	8.5	3.8	7.5	4.3	8.5
PSA 0.5 sec	3.6	7.1	3.3	6.6	3.6	7.1
PSA 1.0 sec	1.9	3.8	2.1	4.3	2.1	4.3
PSA 2.0 sec	1.2	2.4	1.4	2.9	1.4	2.9
PGA	3.3	6.7	2.8	5.5	3.3	6.7
Vancouver (49.2 -123.2)						
PSA 0.1 sec	43	87	44	87	44	87
PSA 0.15 sec	51	100	52	100	52	100
PSA 0.2 sec	50	100	52	110	52	110
PSA 0.3 sec	43	86	46	91	46	91
PSA 0.4 sec	37	75	40	79	40	79
PSA 0.5 sec	33	66	35	70	35	70
PSA 1.0 sec	15	30	18	36	18	36
PSA 2.0 sec	6.6	13	8.9	18	8.9	18
PGA	25	51	26	51	26	51

Western Cities - Spectral values prob 10%/50 years

Spectral Parameter	H Model 50%ile	H Model 84%ile	R Model 50%ile	R Model 84%ile	Robust 50%ile	Robust 84%ile
Victoria (48.5 -123.3)						
PSA 0.1 sec	59	120	53	110	59	120
PSA 0.15 sec	69	140	62	120	69	140
PSA 0.2 sec	68	140	62	120	68	140
PSA 0.3 sec	58	120	53	110	58	120
PSA 0.4 sec	50	100	46	92	50	100
PSA 0.5 sec	45	89	41	81	45	89
PSA 1.0 sec	20	41	20	40	20	41
PSA 2.0 sec	8.7	17	9.6	19	9.6	19
PGA	34	68	31	62	34	68
Tofino (49.1 -125.9)						
PSA 0.1 sec	12	25	20	40	20	40
PSA 0.15 sec	17	34	28	55	28	55
PSA 0.2 sec	18	36	29	58	29	58
PSA 0.3 sec	17	33	27	53	27	53
PSA 0.4 sec	14	28	23	46	23	46
PSA 0.5 sec	12	25	20	40	20	40
PSA 1.0 sec	7.0	14	11	22	11	22
PSA 2.0 sec	4.1	8.1	6.2	12	6.2	12
PGA	9.4	19	14	28	14	28
Prince Rupert (54.3 -130.4)						
PSA 0.1 sec	6.8	13	11	23	11	23
PSA 0.15 sec	10	20	16	33	16	33
PSA 0.2 sec	11	22	18	35	18	35
PSA 0.3 sec	11	22	16	32	16	32
PSA 0.4 sec	10	20	14	28	14	28
PSA 0.5 sec	9.9	20	13	26	13	26
PSA 1.0 sec	7.6	15	8.8	18	8.8	18
PSA 2.0 sec	4.4	8.7	5.1	10	5.1	10
PGA	6.0	12	9.2	18	9.2	18
Queen Charlotte City (53.3 -132.0)						
PSA 0.1 sec	27	53	28	56	28	56
PSA 0.15 sec	37	73	39	78	39	78
PSA 0.2 sec	40	79	43	85	43	85
PSA 0.3 sec	40	79	42	83	42	83
PSA 0.4 sec	37	74	39	77	39	77
PSA 0.5 sec	35	69	36	71	36	71
PSA 1.0 sec	24	47	24	47	24	47
PSA 2.0 sec	13	26	13	26	13	26
PGA	21	42	22	44	22	44
Inuvik (68.4 -133.6)						
PSA 0.1 sec	3.1	6.2	3.1	6.2	3.1	6.2
PSA 0.15 sec	4.8	9.6	4.8	9.6	4.8	9.6
PSA 0.2 sec	5.4	11	5.4	11	5.4	11
PSA 0.3 sec	5.2	10	5.3	11	5.3	11
PSA 0.4 sec	4.5	8.9	4.6	9.2	4.6	9.2
PSA 0.5 sec	3.9	7.7	4.0	8.0	4.0	8.0
PSA 1.0 sec	2.2	4.4	2.3	4.6	2.3	4.6
PSA 2.0 sec	1.4	2.7	1.5	3.0	1.5	3.0
PGA	3.2	6.4	3.2	6.3	3.2	6.4

Notes.

All values are given for a probability of 0.0021 p.a. (10% in 50 years) on firm ground.

[1]Spectral (5% damped) and peak acceleration values are in %g, peak velocity in m/s.

[2]PSA2.0 s epistemic uncertainty to provide the 84th percentile is not available.

Table 5

Proposed Floor values for low seismicity parts of Canada

Median firm ground spectral parameters (%g), peak acceleration (%g) and peak velocity (m/s)

Parameter	Probability level 10%/50 year	Probability level 2%/50 year
PSA 0.1 sec	5.3	16
PSA 0.15 sec	5.9	16
PSA 0.2 sec	6.0	16
PSA 0.3 sec	4.9	12
PSA 0.4 sec	3.7	9.2
PSA 0.5 sec	2.9	7.5
PSA 1.0 sec	1.1	2.9
PSA 2.0 sec	0.3	1.0
PGA	3.4	11
PGV	0.019	0.045

Table 6

Hazard Values for Cascadia Subduction Earthquake Scenario, ordered by distance, using Youngs et al. 1997 Attenuation

	Tofino		Victoria		Vancouver		Kamloops		Kelowna		Prince George		Calgary	
Distance (km)	40		80		160		410		410		560		860	
Percentile	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%	50%	84%
Period (s)														
0.1	39	74	26	49	13	24	2.9	5.5	2.9	5.5	1.6	3.0	0.6	1.2
0.15	46	86	31	58	16	29	3.7	6.9	3.7	6.9	2.0	3.8	0.8	1.6
0.2	48	90	33	62	17	31	4.1	7.6	4.1	7.6	2.3	4.3	1.0	1.8
0.3	44	83	31	57	16	30	4.0	7.5	4.0	7.5	2.3	4.3	1.0	1.8
0.4	41	77	28	54	15	28	3.9	7.3	3.9	7.3	2.2	4.2	1.0	1.8
0.5	38	72	27	50	14	27	3.8	7.1	3.8	7.1	2.2	4.2	1.0	1.8
1	20	37	14	26	7.7	14	2.2	4.1	2.2	4.1	1.3	2.5	0.6	1.2
2	7.8	16	5.7	12	3.2	6.7	1.0	2.1	1.0	2.1	0.6	1.3	0.3	0.6
PGA	21	39	14	27	7.1	14	1.7	3.2	1.7	3.2	1.0	1.8	0.4	0.7

Notes

The scenario event has a magnitude of 8.2 and is located at a depth of 25 km at given distances from the cities.

Seismic hazard levels are given in units of %g for Peak Ground Acceleration (PGA) and spectral (5% damped) values on firm ground.

Columns labeled "50%" are the medians, which are exceeded half of the time.

Columns labeled "84%" are the 84th percentiles, which are exceeded only 16% of the time (at present the 84th percentile values include only the estimated epistemic uncertainty assumed for the strong ground motion relations).

Use "50%" columns for the 10%/50 year deterministic Cascadia subduction earthquake scenario, and "84%" columns for the 2%/50 year scenario

Table 7. Selected seismic hazard values at 0.000404 per annum for "Firm Ground"

City	Coordinates °North	°West	PGV (m/s) 50% H	PGA (%g) 50% H	0.2 s PSA (%g) 50% H	0.2 s PSA 50% R	0.2 s PSA 84% H	0.2 s PSA 84% R	1.0 s PSA (%g) 50% H	1.0 s PSA 50% R	1.0 s PSA 84% H	1.0 s PSA 84% R	1.0 s PSA (%g) 84% Cascadia
St. John's	47.6	52.7	0.048	8.4	*15*	18	27	31	4.5	6.0	13	16	**see**
Halifax	44.6	63.6	0.052	8.5	16	23	29	41	5.1	7.0	14	19	**note**
Moncton	46.1	64.8	0.095	21	30	28	52	49	6.8	6.5	22	20	
Fredericton	45.9	66.6	0.11	23	35	39	62	69	8.6	8.1	26	27	
La Malbaie	47.6	70.1	0.62	110	230	65	380	100	59	13	180	41	
Quebec	46.8	71.2	0.14	28	52	59	89	100	14	11	44	37	
Trois-Rivieres	46.3	72.5	0.11	20	35	64	62	110	10	12	29	40	
Montreal	45.5	73.6	0.17	37	58	71	97	110	13	14	38	44	
Ottawa	45.4	75.7	0.13	25	45	67	85	110	10	14	31	42	
Niagara Falls	43.1	79.1	0.13	30	41	21	93	38	7.1	5.5	25	15	
Toronto	43.7	79.4	0.081	20	28	20	55	34	4.9	5.4	17	14	
Windsor	42.3	83.0	*0.038*	*5.9*	*12*	17	21	32	*2.4*	3.9	8.4	11	
Calgary	51.0	114.0	**see**	*8.8*	*15*	*9.7*	29	19	4.1	3.2	8.0	6.4	1.2
Kelowna	49.9	119.4	**note**	14	27	19	55	37	8.6	8.9	17	18	4.1
Kamloops	50.7	120.3		14	28	20	55	40	8.5	10	17	20	4.1
Prince George	53.9	122.7		*7.1*	*13*	*9.3*	26	19	4.0	3.8	8.0	7.6	2.5
Vancouver	49.2	123.2		48	96	100	190	200	30	34	60	69	14
Victoria	48.5	123.3		62	120	110	250	230	38	38	77	75	26
Tofino	49.1	125.9		16	32	63	65	130	12	24	24	48	37
Prince Rupert	54.3	130.4		10	19	36	39	72	13	16	26	32	**see**
Queen Charlotte	53.3	132.0		34	63	65	130	130	45	50	91	100	**note**
Inuvik	68.4	133.6		*6.0*	*10*	*8.7*	20	17	3.7	3.9	7.4	7.8	

This summary of seismic hazard results is selected from the values in Tables 3 and 6. Values in *italics* are below the Floor values in Table 5.

Abbreviations: PGV - peak ground velocity; PGA - peak ground acceleration; 0.2 s PSA - pseudo-spectral acceleration at 0.2 seconds; 1.0 s PSA - pseudo-spectral acceleration at 1.0 seconds; RGC - reference ground condition.

Eastern RGC multiplicative factors (in brackets) as follows: PGV (2.38), PGA (1.39), 0.2 s (1.94), 1.0 s (2.58). Eastern hard rock values can be found by dividing by the appropriate RGC factor; RGC factors are not applicable for the west.

The columns labelled "50%" are the medians, which are exceeded half of the time. The columns labelled "84%" are the 84th percentiles, which are exceeded only 16% of the time.

Columns labelled 'H' and 'R' are the hazard values for the probabilistic models discussed in the text; 'Cascadia' is the Cascadia scenario event.

note: PGV values are not available for the west; Cascadia values are given only where relevant.

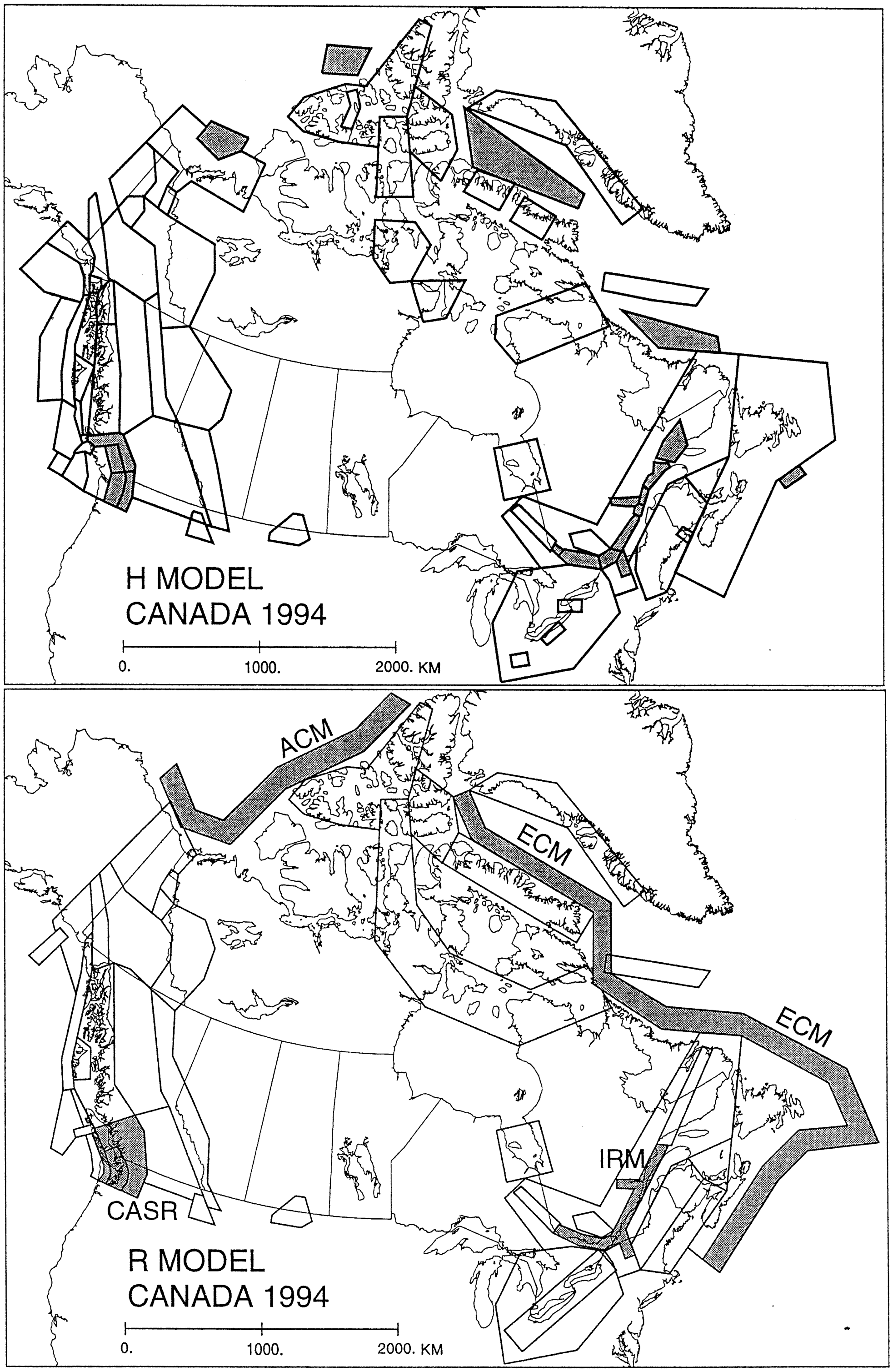


Figure 1. Earthquake source zone maps of Canada showing the zones that form the H (top) and R (bottom) models for earthquake distribution. Zones referred to in the text are shaded and labelled on the bottom map; corresponding H-model zones are shaded on the top map.

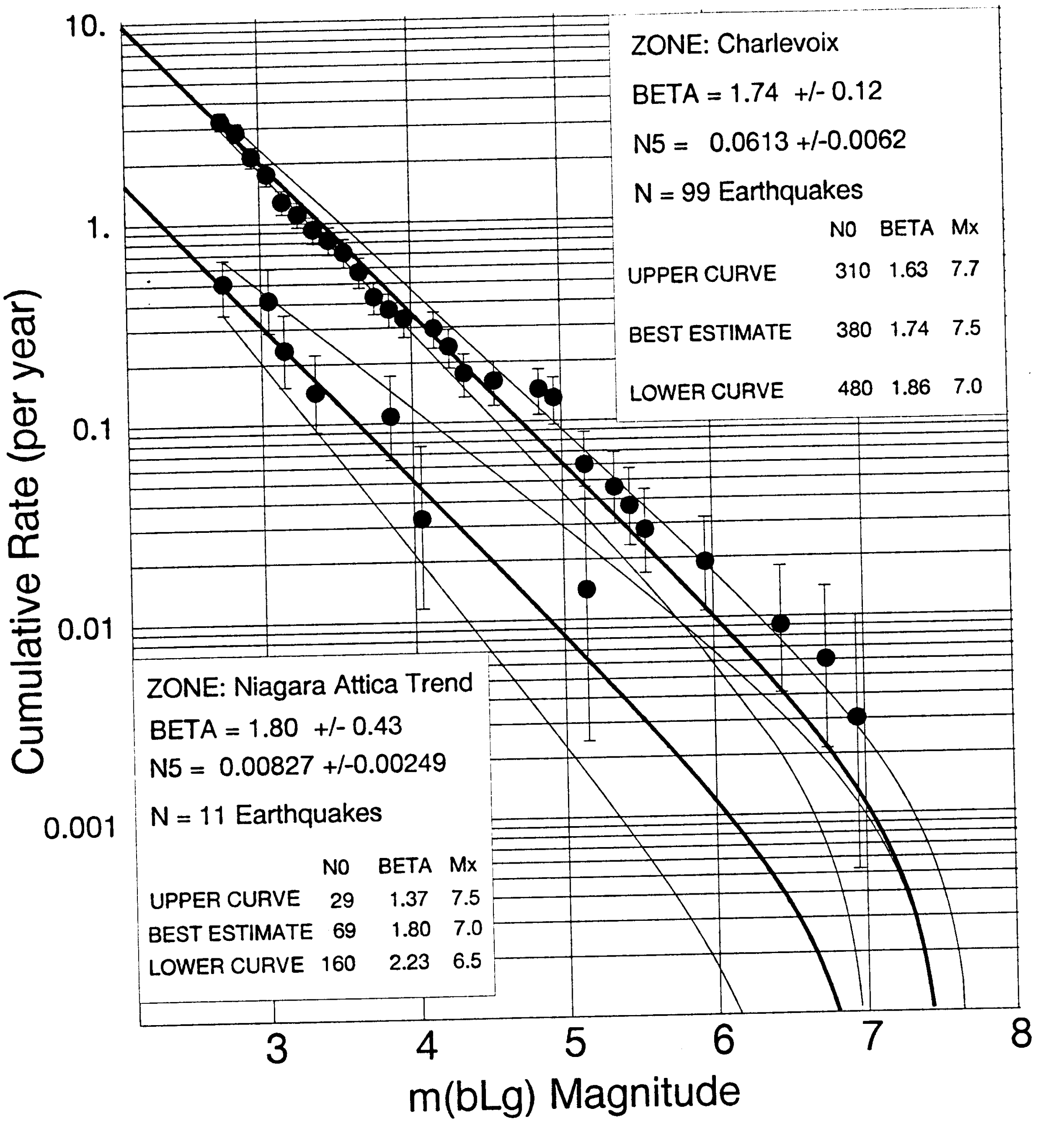


Figure 2. Sample magnitude-recurrence data and curves, for Charlevoix and the Niagara-Attica Trend (NAT) zones. The cumulative rates of earthquakes are represented by solid circles with stochastic error bounds and the best-fit curve (bold) are flanked by upper and lower "error" curves that are more widely separated for the poorly-constrained NAT dataset. All curves are asymptotic to assumed upper bound magnitudes.

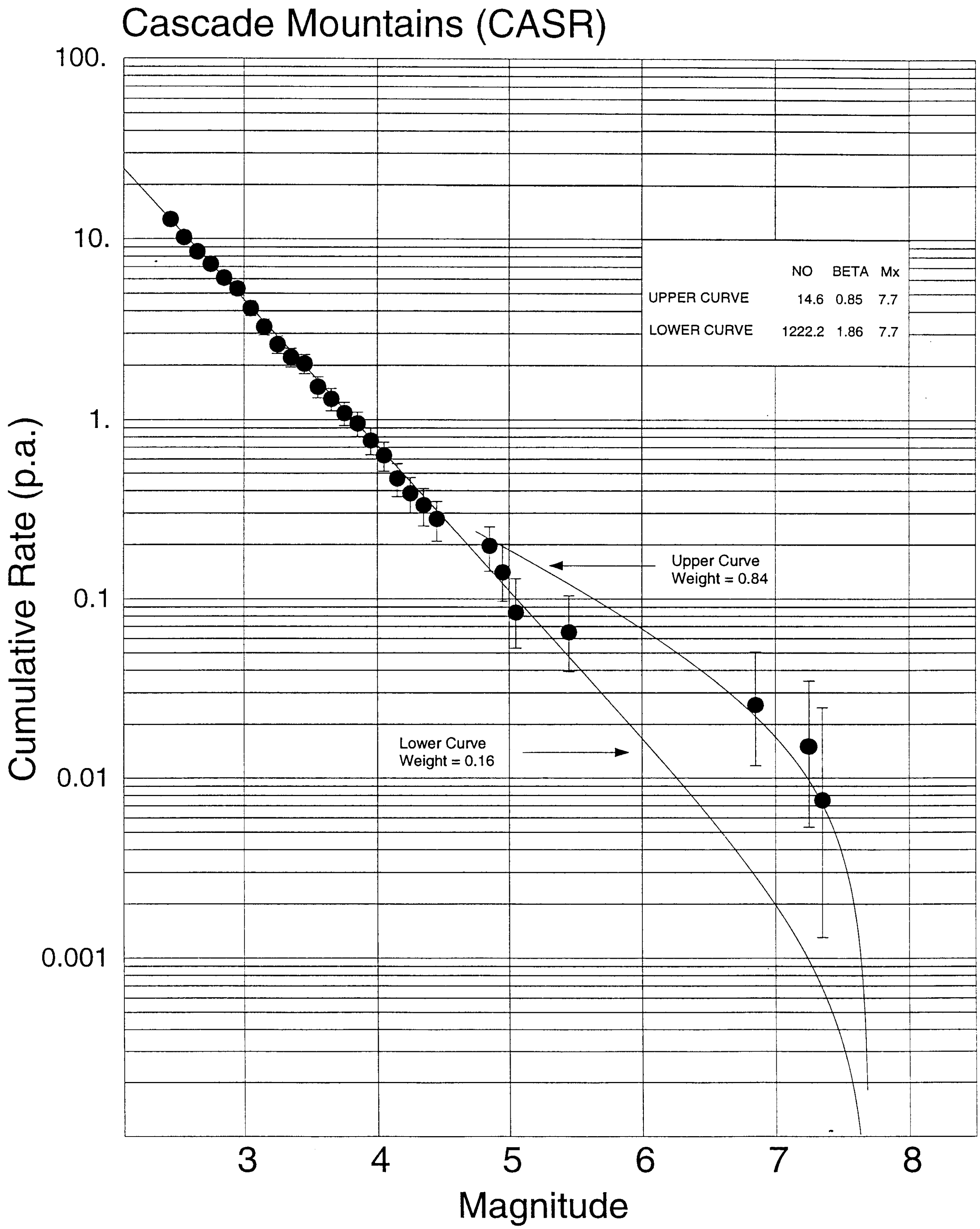


Figure 3. Magnitude-recurrence data and curves for CASR, the shallow crustal source for the Strait of Georgia - Puget Sound region. The maximum likelihood fit including the small magnitude earthquakes (lower curve) passes through the point (0.002, 7.0), considerably below the historical rate of M>6.8 earthquakes. The maximum likelihood fit to only M>4.75 earthquakes (upper curve) matches the historical rate of larger earthquakes much better. Both curves are asymptotic to assumed upper-bound magnitudes.

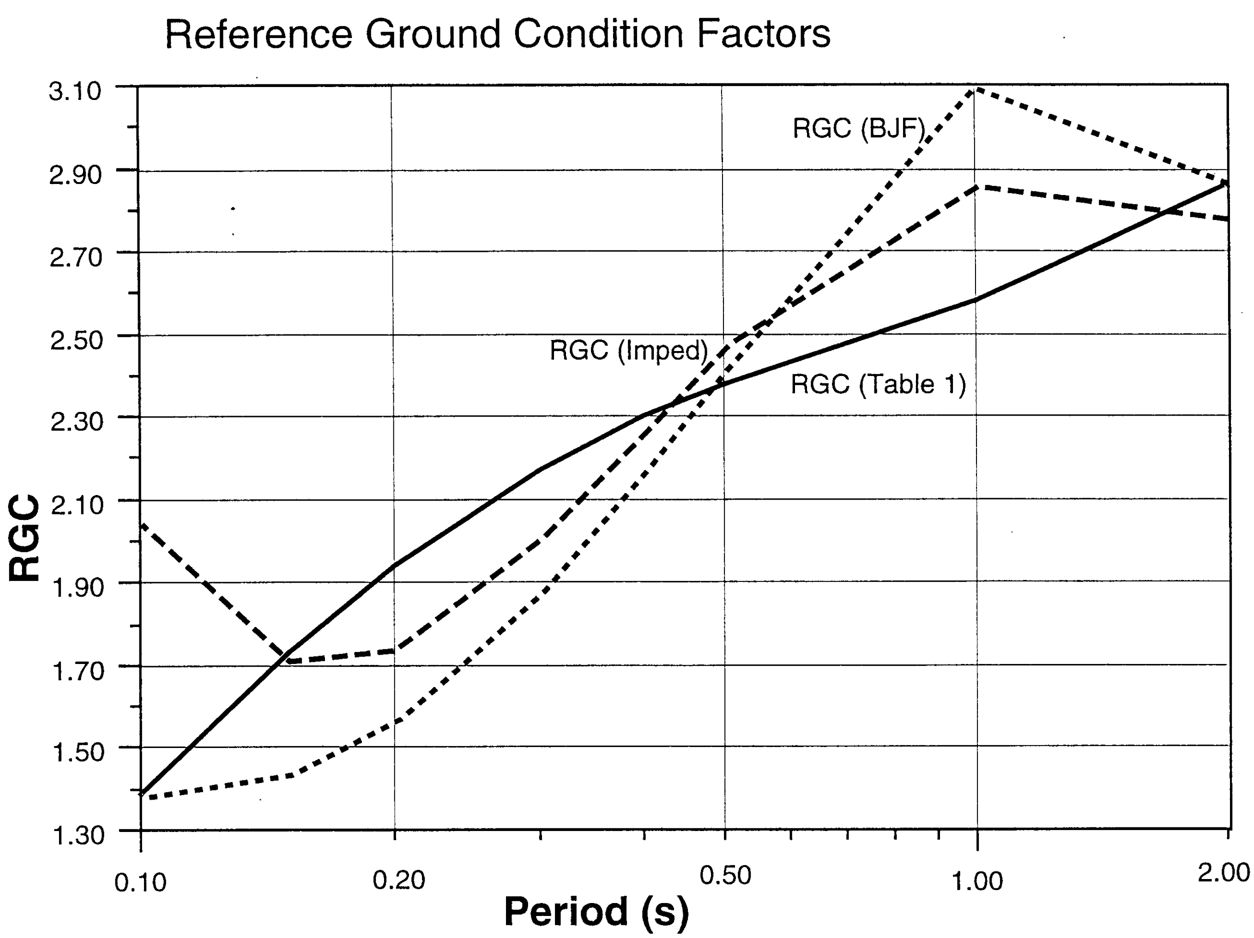


Figure 4. RGC factors as a function of period, as derived by the three methods described in the text and shown in Table 2. The "Table 1" factors are the preferred ones.

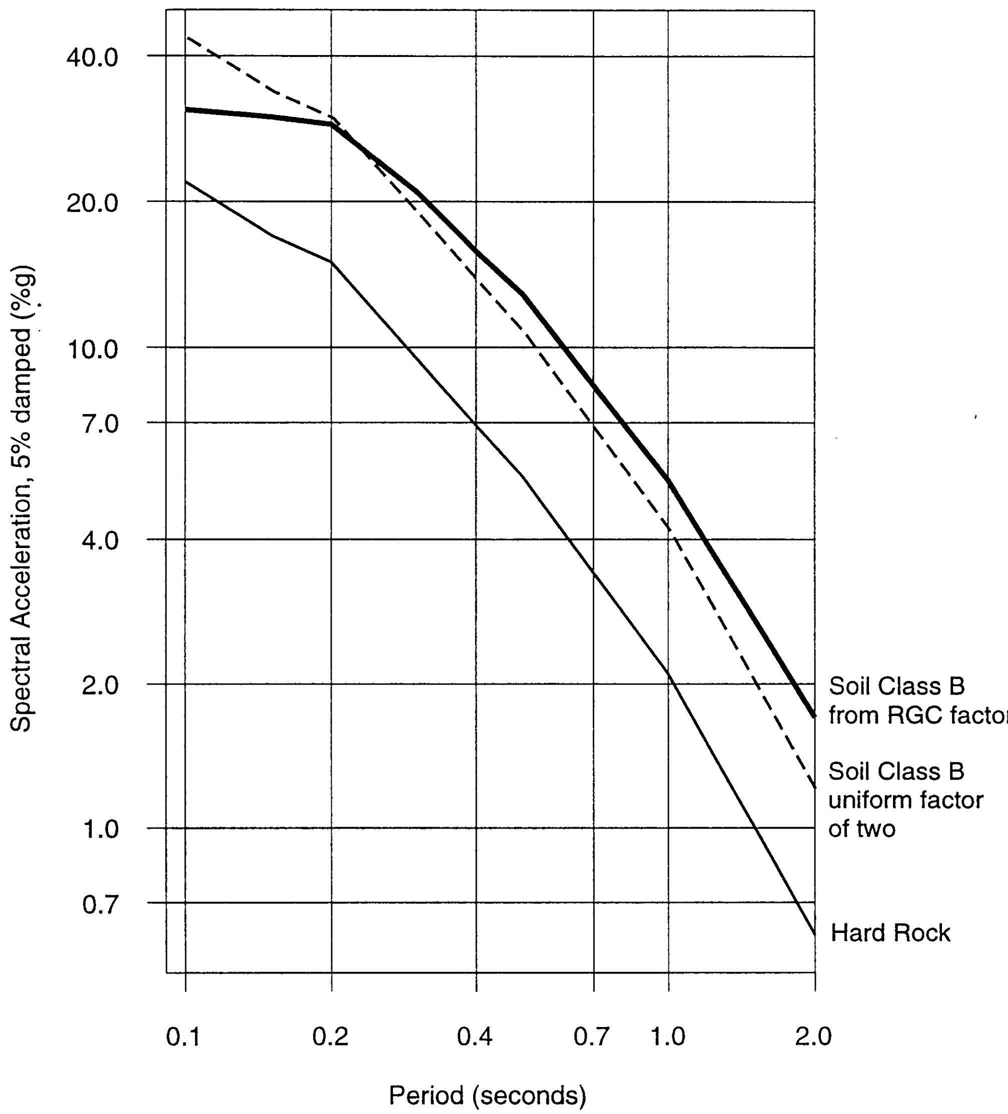


Figure 5. Seismic hazard for Montreal depicted as Uniform Hazard Spectra on various ground conditions. These 50th percentile UHS from the **R** model are derived from values given in Table 4 for hard-rock and soil Class B using the RGC factors; a baseline derived from the hard-rock values using a uniform amplification of a factor of two is shown for comparison.

Figures 6-27 show the 0.0021 and 0.000404 per annum ground motion "firm ground" results as Uniform Hazard Spectra for the named city. For each probability, the 50th percentile (solid line) and 84th percentile (dotted line) UHS are derived by the robust method from the **H** and **R** model values given in Tables 3 or 4. For southwestern Canadian cities, two additional curves (dashed lines) are shown. These are the 50th and 84th percentile spectra for the scenario M8.2 Cascadia event, as given in Table 6.

Figure 6. St. John's	Figure 7. Halifax	Figure 8. Moncton
Figure 9. Fredericton	Figure 10. La Malbaie	Figure 11. Quebec
Figure 12. Trois-Rivières	Figure 13. Montreal	Figure 14. Ottawa
Figure 15. Niagara Falls	Figure 16. Toronto	Figure 17. Windsor
Figure 18. Calgary	Figure 19. Kelowna	Figure 20. Kamloops
Figure 21. Prince George	Figure 22. Vancouver	Figure 23. Victoria
Figure 24. Tofino	Figure 25. Prince Rupert	
Figure 26. Queen Charlotte City	Figure 27. Inuvik	

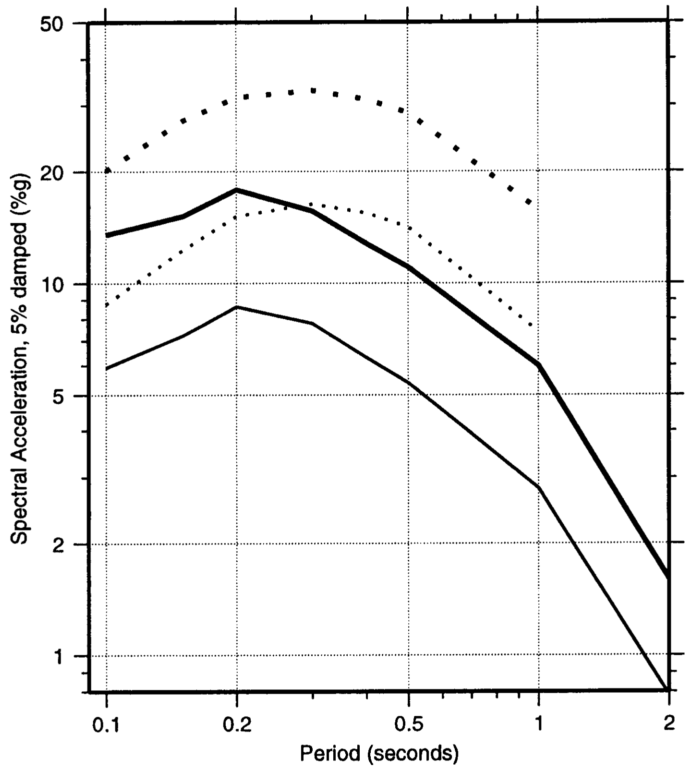


Figure 6. St. John's "Robust" Uniform Hazard Spectra

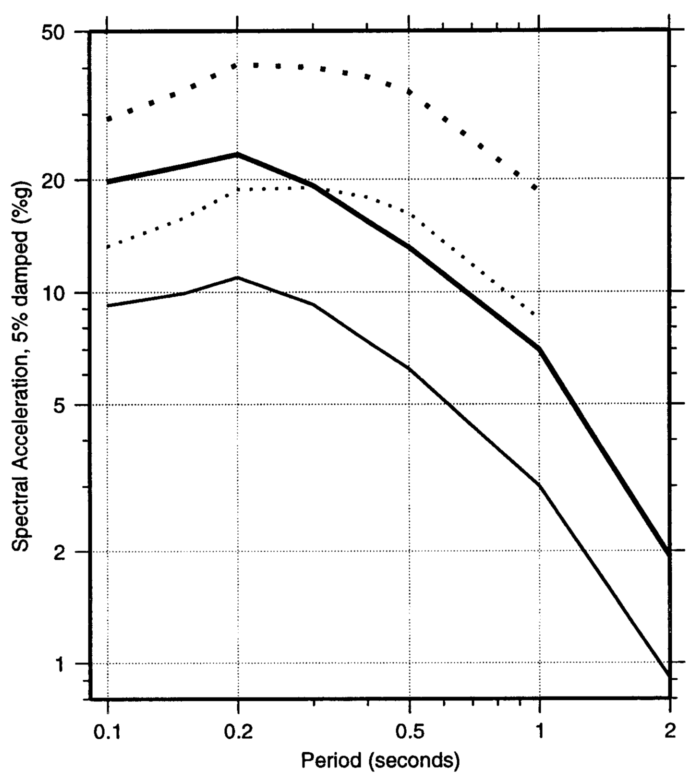
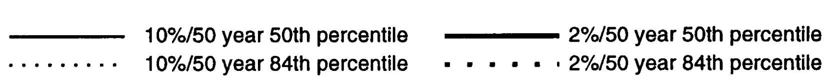


Figure 7. Halifax "Robust" Uniform Hazard Spectra



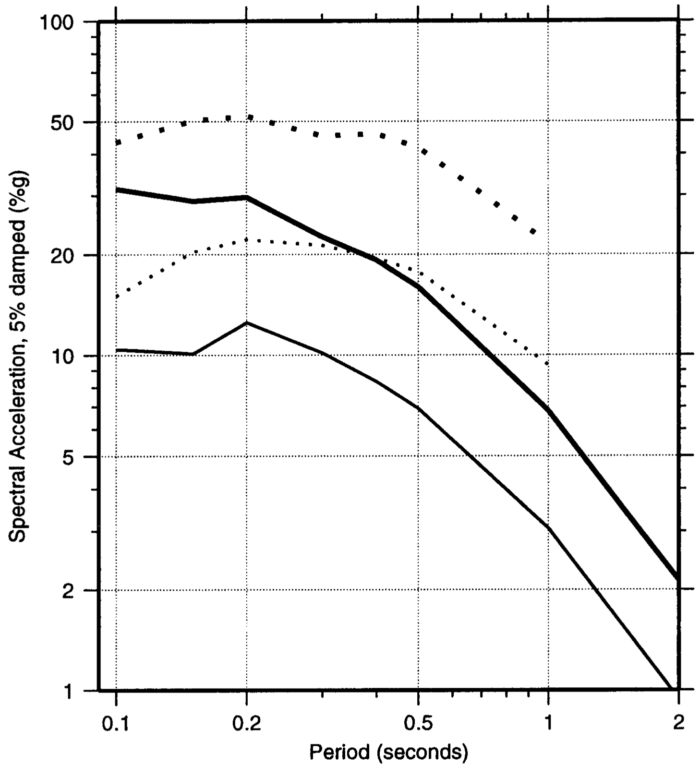


Figure 8. Moncton "Robust" Uniform Hazard Spectra

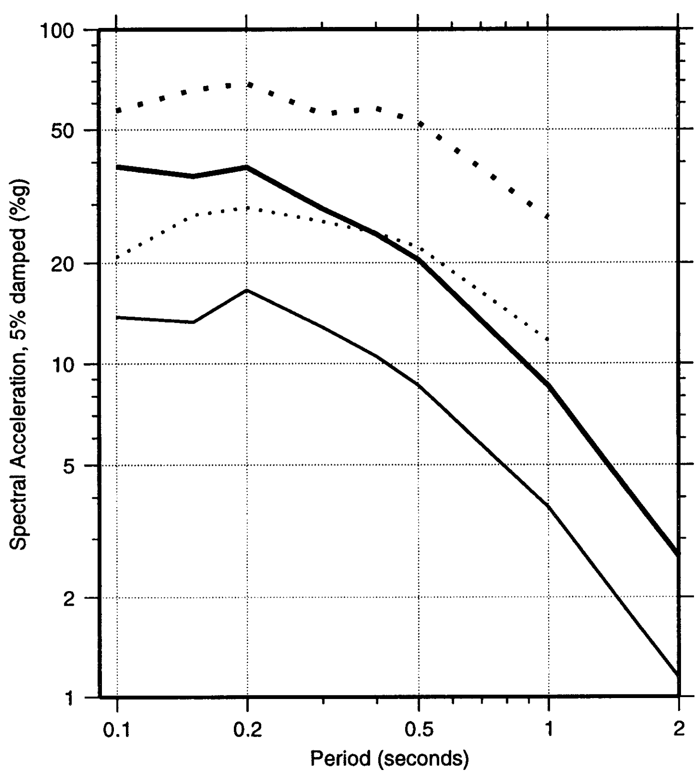


Figure 9. Fredericton "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile

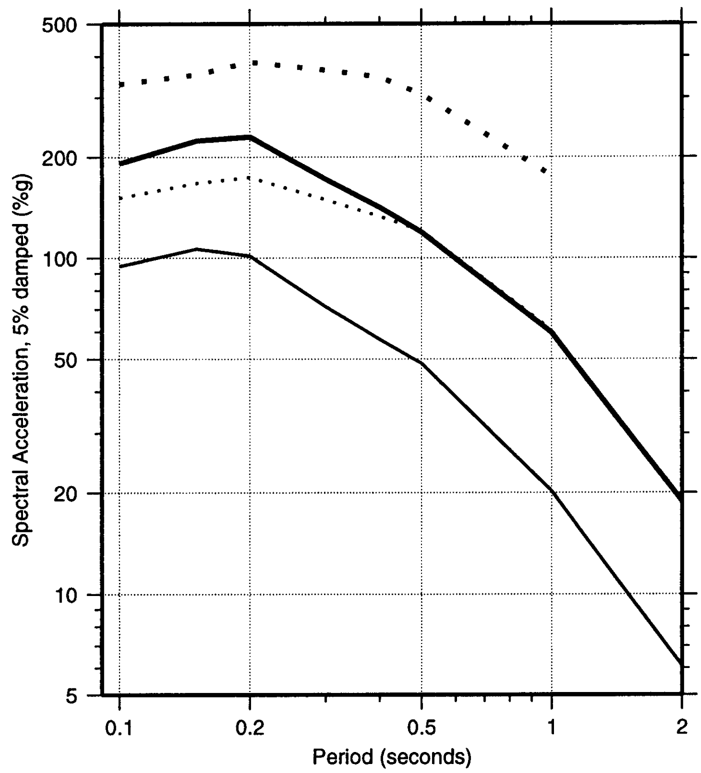


Figure 10. La Malbaie "Robust" Uniform Hazard Spectra

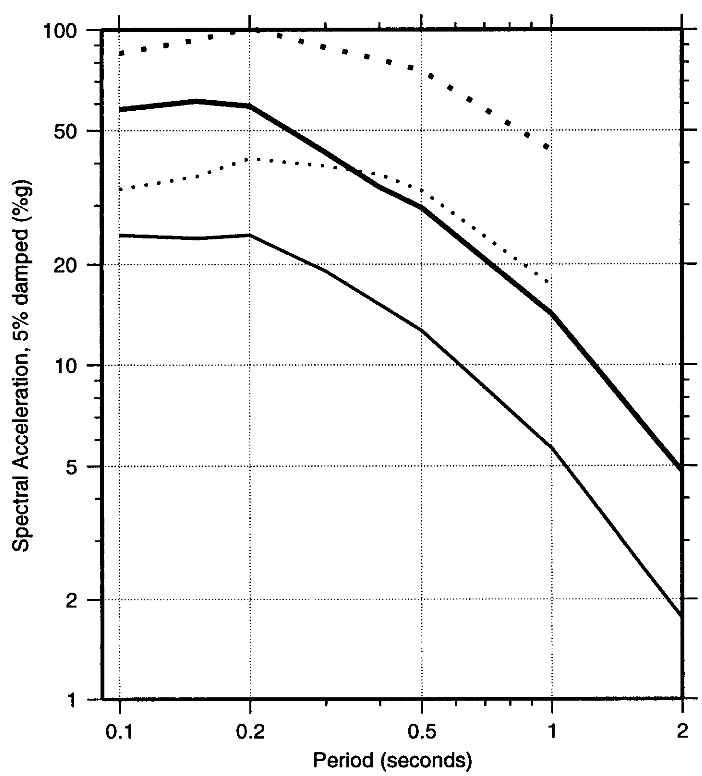


Figure 11. Quebec "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile

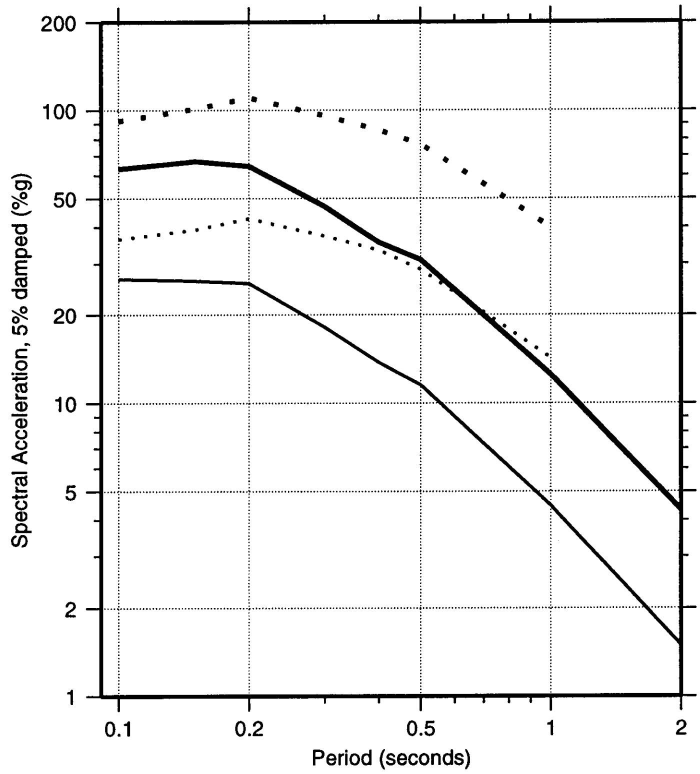


Figure 12. Trois-Rivieres "Robust" Uniform Hazard Spectra

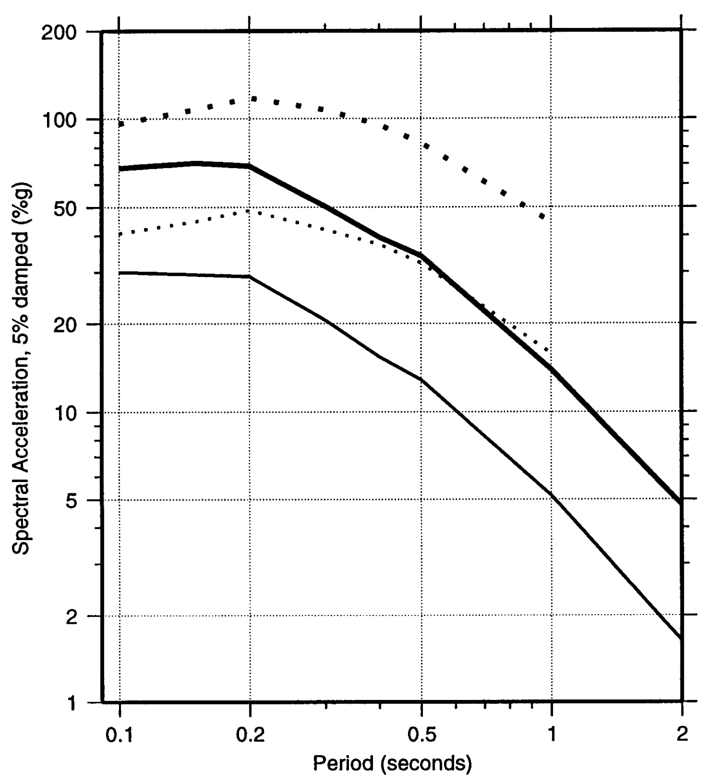
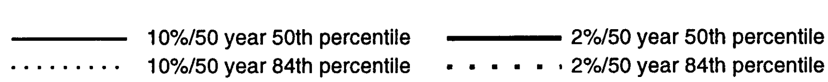


Figure 13. Montreal "Robust" Uniform Hazard Spectra



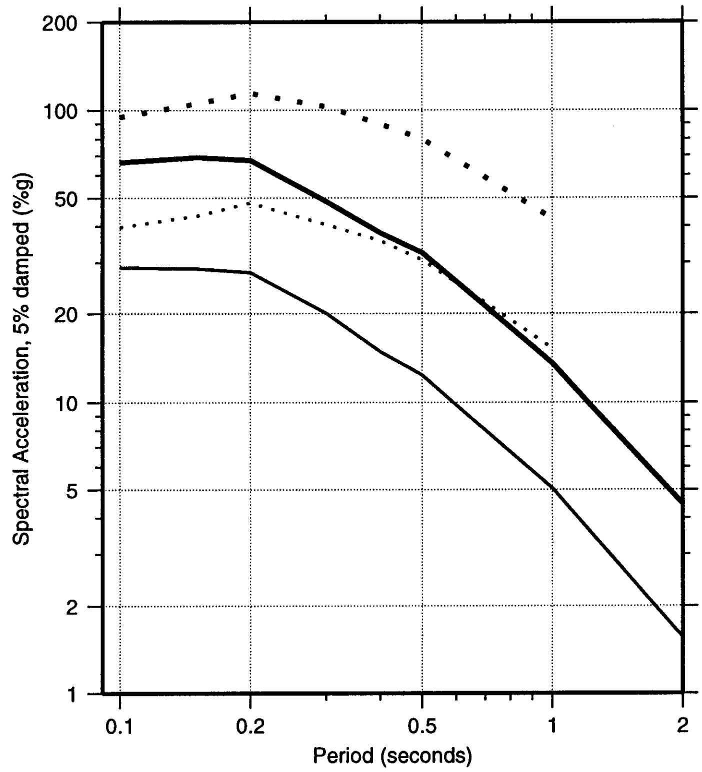


Figure 14. Ottawa "Robust" Uniform Hazard Spectra

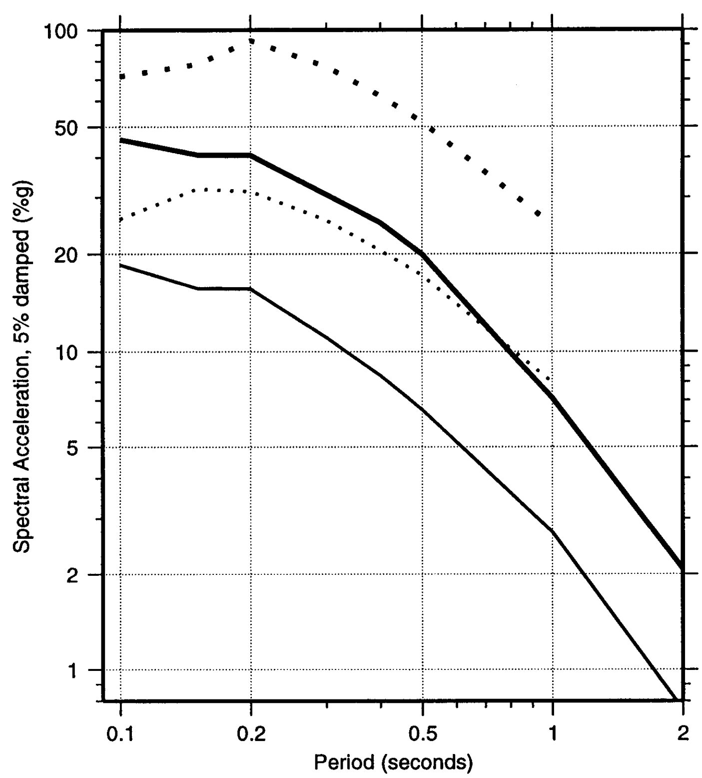


Figure 15. Niagara Falls "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
2%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 84th percentile

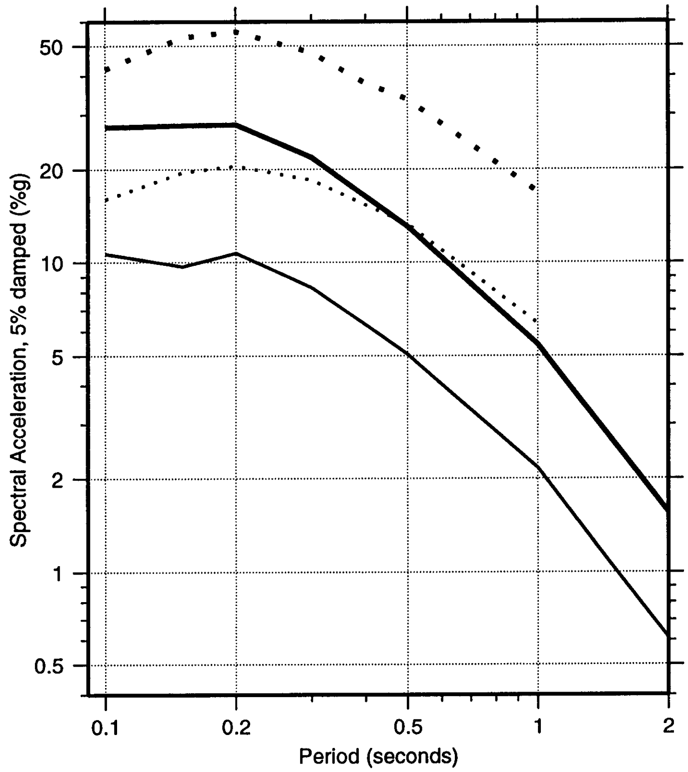


Figure 16. Toronto "Robust" Uniform Hazard Spectra

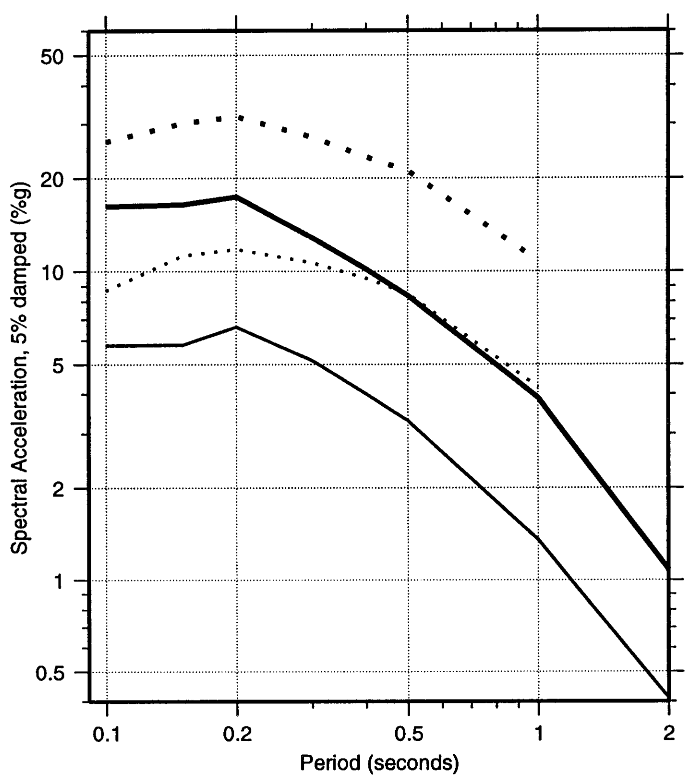


Figure 17. Windsor "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile

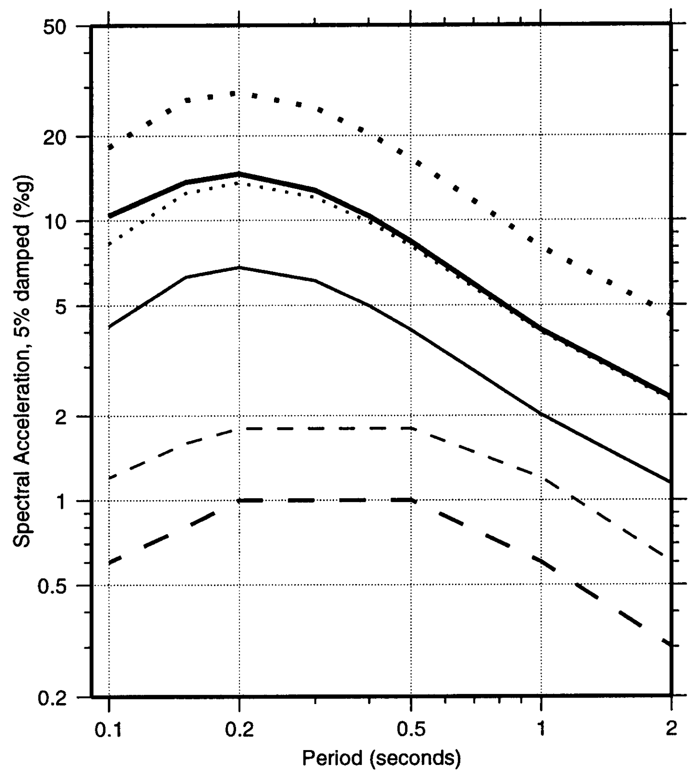


Figure 18. Calgary "Robust" Uniform Hazard Spectra

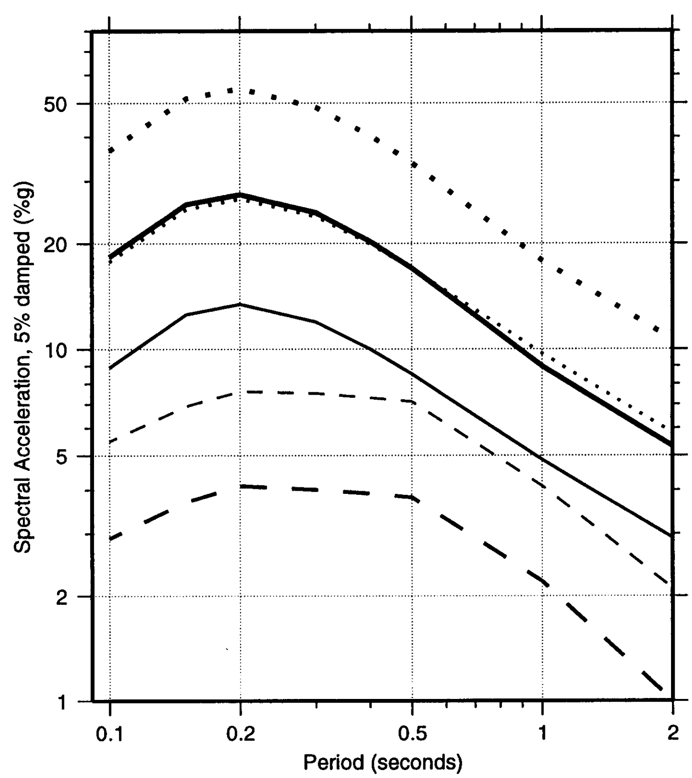


Figure 19. Kelowna "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile	2%/50 year 50th percentile	Cascadia 50th percentile
10%/50 year 84th percentile	2%/50 year 84th percentile	Cascadia 84th percentile

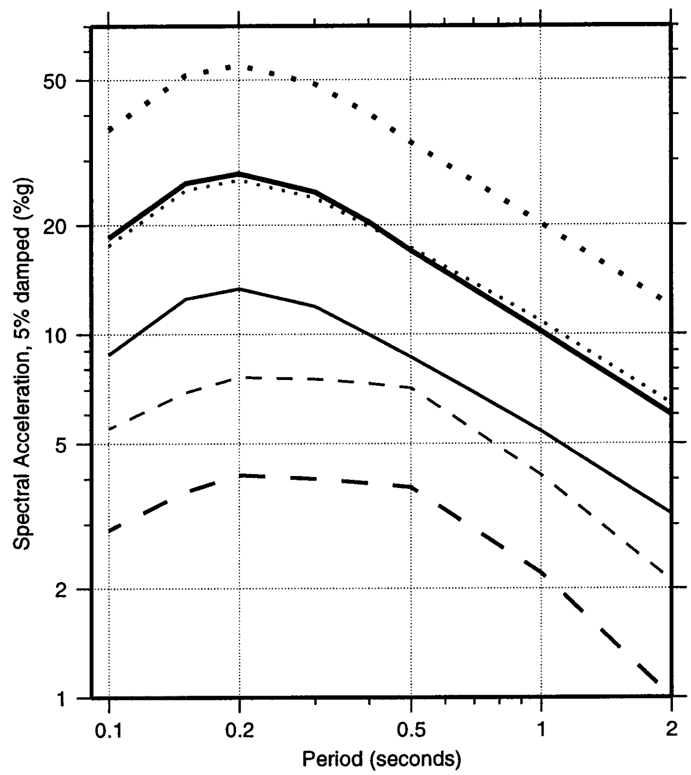


Figure 20. Kamloops "Robust" Uniform Hazard Spectra

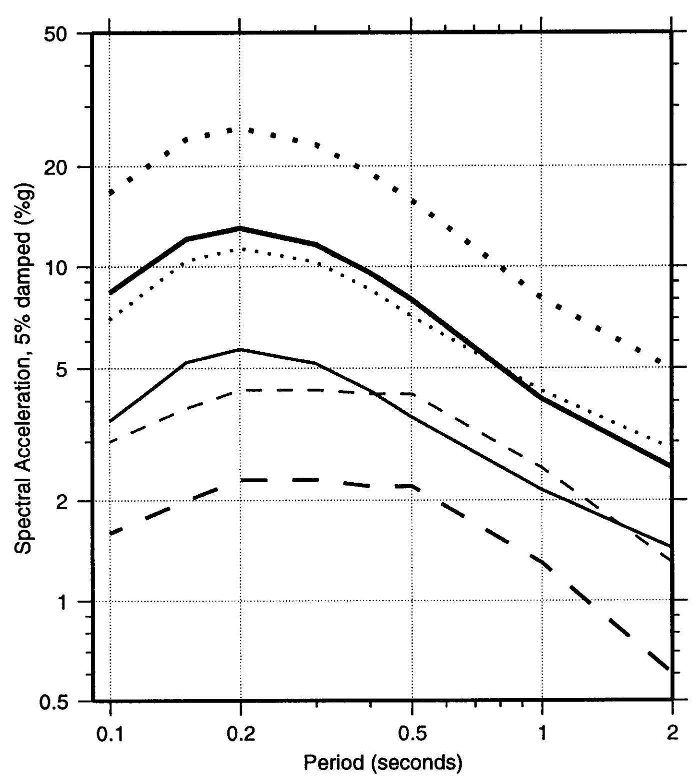


Figure 21. Prince George "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile
Cascadia 50th percentile
Cascadia 84th percentile

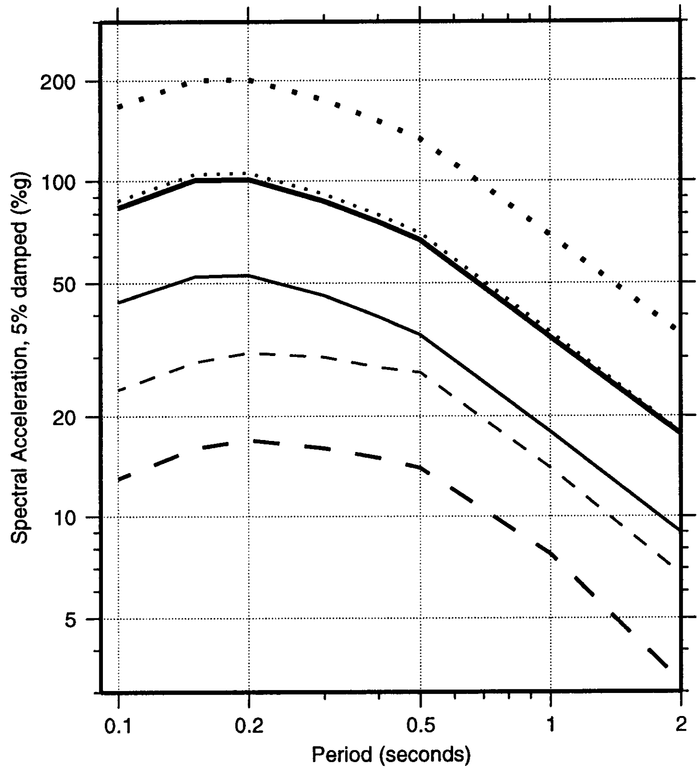


Figure 22. Vancouver "Robust" Uniform Hazard Spectra

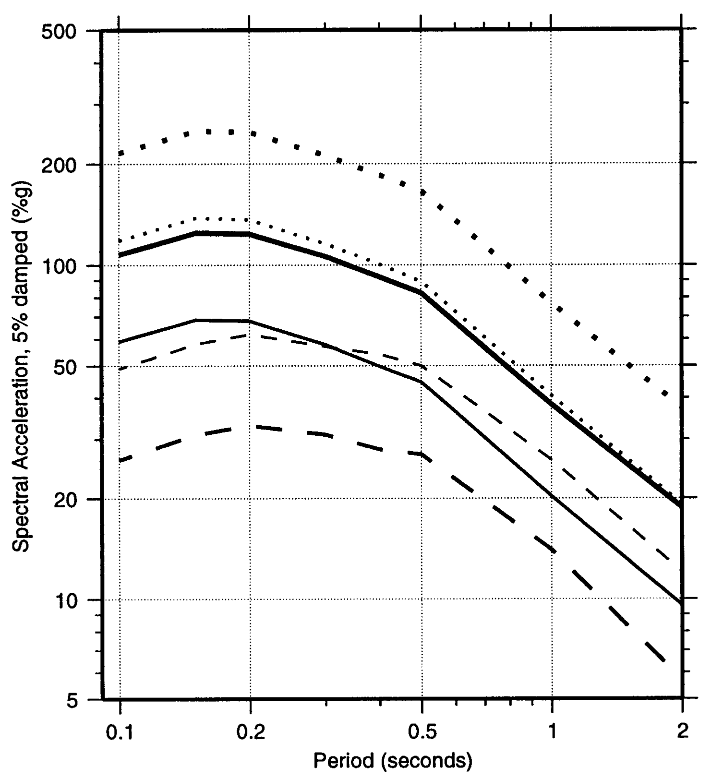


Figure 23. Victoria "Robust" Uniform Hazard Spectra

——— 10%/50 year 50th percentile	——— 2%/50 year 50th percentile	— — — Cascadia 50th percentile
········· 10%/50 year 84th percentile	• • • • • 2%/50 year 84th percentile	- - - - Cascadia 84th percentile

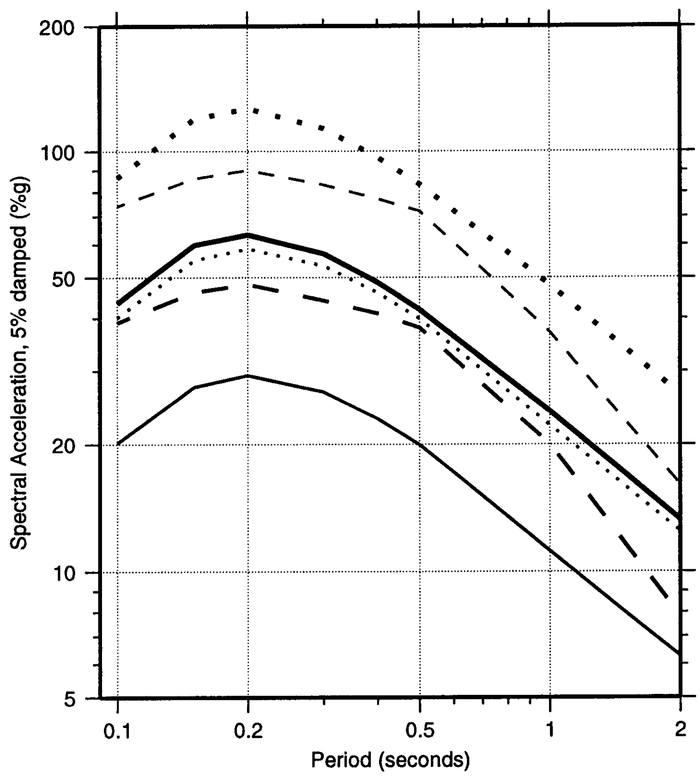


Figure 24. Tofino "Robust" Uniform Hazard Spectra

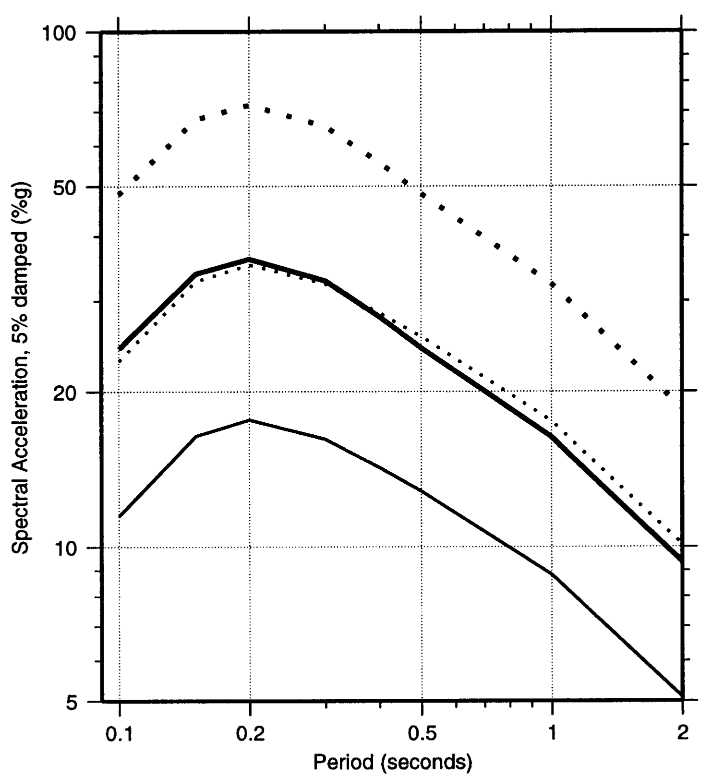


Figure 25. Prince Rupert "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile
Cascadia 50th percentile
Cascadia 84th percentile

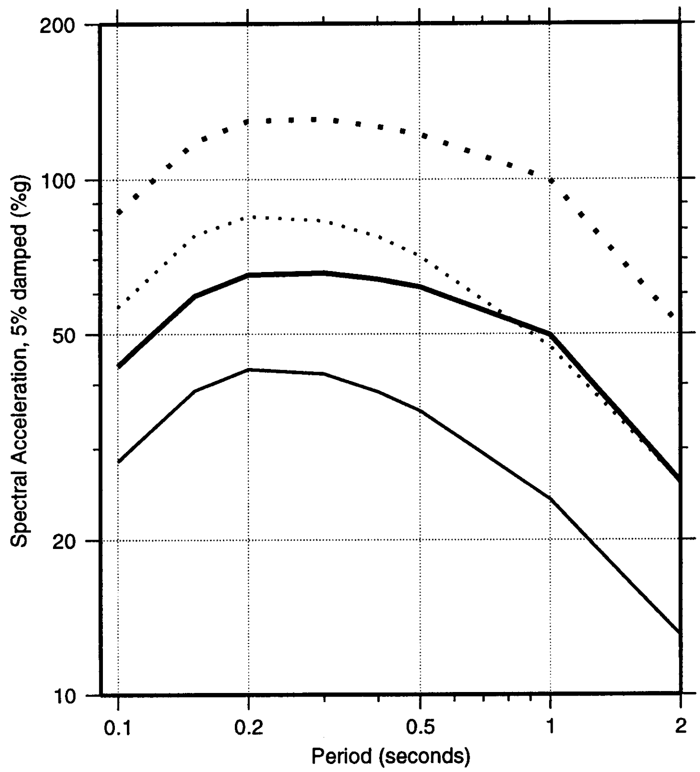


Figure 26. Queen Charlotte City "Robust" Uniform Hazard Spectra

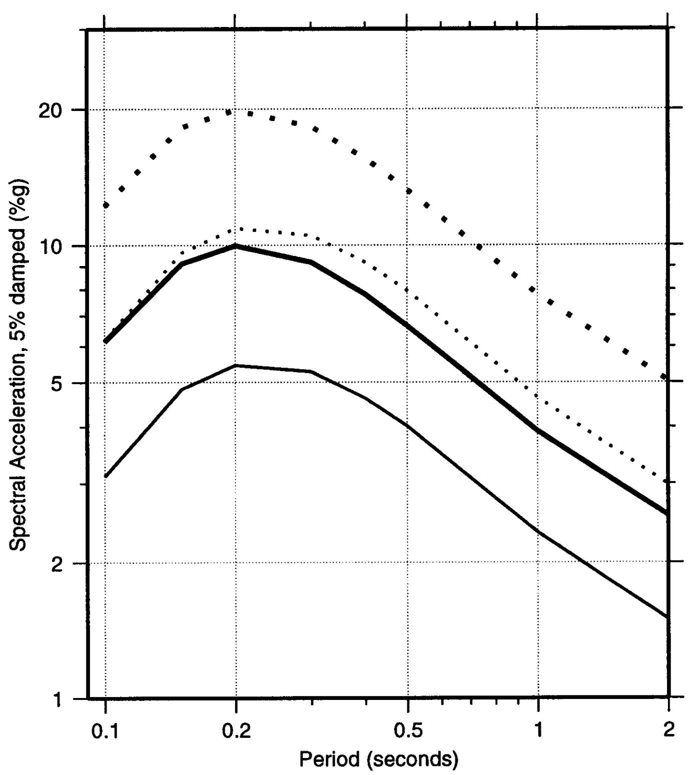


Figure 27. Inuvik "Robust" Uniform Hazard Spectra

10%/50 year 50th percentile
10%/50 year 84th percentile
2%/50 year 50th percentile
2%/50 year 84th percentile

APPENDICES

A1. Summary of changes since GSC Open File 3283

A2. Summary of changes between GSC Open File 3029 and GSC Open File 3283

A3. Justification for using the Youngs et al. (1997) relations for western subcrustal earthquakes

A4. Rationale for using the 2%/50 year probability level hazard results

B. Alternative approaches for computing Reference Ground Condition factors.

C. The 1995 seismicity models for probabilistic hazard

D. Input models for FRISK88 seismic hazard code (including strong ground motion parameters).

E. Published information relevant to the derivation of RGC factors

APPENDIX A1

Summary of Changes since GSC Open File 3283

Philosophy (by iteration between seismologists and engineers)
Request to provide 2%/50 year values as the proposed basis for seismic provisions in the National Building Code of Canada.

Source zones and Earthquake recurrence rates
No changes to probabilistic models
A floor level has been added for the low seismicity parts of Canada

SGM relations - East
No changes

SGM relations - West
Youngs et al. relations used for in-slab and subduction interface events as a replacement for Crouse's. See text of Open File and Appendix A3. A summary of the consequent changes in hazard are given as Table A1.1, together with the difference in the Vancouver UHS as Figure A1-1.

Calculation program:
Imprecision was found to be occurring in some of the computation due to using too few control points to interpolate values and to the subdivision of the seismic zones into too few computational slices. Test computations were made to increase both until optimal values were found, and 24 interpolation points at approximately 0.125 log unit intervals 50 slices, resulting in an 8-fold increase in computation time.

All calculations in this Open File were made with the revised number of slices and control points. Table A1-2 shows the changes from the previous Open File 10%/50 year results. In eastern Canada the magnitude of the average change (i.e. independent of sign) is 4.2%, the average change is -0.7%, and just one tenth of the values change by more than 10%, the two largest changes being 24% and 21% for Halifax. In western Canada the magnitude of the average change is 2.8%, the average change is +1.7%, and just two values change by more than 10%, PSA0.15 sec at Vancouver and Victoria. For all of Canada, the magnitude of the average change is 3.6% and the average change just +0.3%.

Blunders
None

Significant changes in hazard relative to past code values

(Note some relative hazard levels have changed due the the move from the 10%/50 year to the 2%/50 year values)

East - Major changes, as judged by the change in 10%/50 year hazard, for backward comparability, are:

La Malbaie. For our current estimates, the H model hazard is larger than the R. The size of the Charlevoix zone in the H model is smaller than that used in 1985 (reflecting more confidence in the boundaries of the highly-active zone). This increases the hazard slightly.

Quebec City. In the 1985 NBCC, the seismic design in Quebec City was dominated by shaking from large earthquakes in the Charlevoix seismic zone, about 80-160 km downstream. Relative to the Atkinson/Boore 1995 ground motions we are now using, the HBB relations used for NBCC85 have a slower diminution of shaking with distance and a stronger magnitude scaling (i.e., for a given magnitude increment HBB predicts a larger increase in shaking than AB95). Both differences mean that Quebec City shaking from Charlevoix earthquakes (H model) is now predicted to be much less. Indeed, that component of shaking is now not much greater than that from earthquakes in the IRM zone of the alternative R model (see also note 3).

Quebec City, Trois Rivières, Montreal, and Ottawa. Their new design levels are almost identical. For the latter three sites, this reflects the dominance of the IRM zone of the R model, in which rates of large earthquakes along the Ottawa and St. Lawrence rivers are considered uniform. The increase from the 1985 code reflects the higher rate of large earthquakes in the IRM zone (obtained by spreading-out the Charlevoix seismicity) relative to the spatial equivalent 1985 zones. In detail (e.g., see tables in this Open File) the hazard in Montreal is slightly higher that the others because it is at a junction of the IRM zone and receives contributions from three directions (cf Trois Rivières, two; 14 cm/sec/sec vs 12 for PSA1).

West

Prince George	Longer period robust values no longer dominated by Cascadia earthquake
Vancouver	hazard increased by about 17% due to use of Youngs et al. relationship
Victoria	hazard increased by about 30% due to use of Youngs et al. relationship; Victoria is now significantly higher than Vancouver
Tofino	hazard increased by recognition of Cascadia subduction zone.

Table A1-1

Robust median 10%/50 year Values for Western Cities, comparing Crouse vs Youngs

Note that the values were calculated in September 1998, prior to the improved precision in computational parameters

	Tofino			Victoria			Vancouver			Kamloops			Kelowna			Prince George			Calgary		
Attenuation	C	Y	%	C	Y	%	C	Y	%	C	Y	%	C	Y	%	C	Y	%	C	Y	%
Period (s)																					
0.1	*27*	*39*	44	41	56	37	35	41	17	10	9.1	-9	11	9.2	-16	3.7	3.7	0	4.2	4.2	0
0.15	*30*	*46*	53	47	65	38	42	49	17	13	13	0	14	13	-7	5.2	5.2	0	6.1	6.1	0
0.2	*37*	*48*	30	57	64	12	48	50	4	15	13	-13	15	14	-7	5.7	5.7	0	6.7	6.7	0
0.3	*33*	*44*	33	40	54	35	38	44	16	13	12	-8	13	12	-8	5.1	5.1	0	5.7	5.7	0
0.4	*29*	*41*	41	35	47	34	33	38	15	11	10	-9	11	10	-9	*4.8*	4.3	-10	4.6	4.6	0
0.5	*28*	*38*	36	30	42	40	28	35	25	8.8	8.7	-1	8.8	8.5	-3	*4.0*	3.6	-10	4.1	4.1	0
1.0	*20*	*20*	0	15	19	27	15	17	13	5.2	5.2	0	4.6	4.7	2	*2.8*	2.1	-25	2.0	2.0	0
2.0	*6.7*	*7.8*	16	7.6	9.7	28	7.6	8.9	17	3.2	3.2	0	2.9	2.9	0	*1.5*	1.4	-7	1.2	1.2	0
PGA	22	*21*	-5	22	34	55	19	25	32	6.9	7.0	1	6.9	7.0	1	3.5	3.5	0	4.0	4.0	0

Italicized values indicate those spectral values that are dominated by the Cascadia scenario

Table A1 - 2

Change, due to improved precision in computational parameters, in new robust 10%/50 year values for cities from values in GSC Open File 3283

	PSA 0.1 sec		PSA 0.15 s		PSA 0.2 sec		PSA 0.3 sec		PSA 0.4 sec		PSA 0.5 sec		PSA 1.0 sec		PSA 2.0 sec		PGA		PGV	
	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*
St. John's	5.9	*0.2*	7.2	*-1.7*	8.6	*-2.7*	7.8	*-6.1*	6.3	*-10.3*	5.4	*-7.9*	2.8	*-9.3*	0.8	*-12.9*	3.6	*-10.8*	0.029	*-7.7*
Halifax	9.2	*24.1*	9.9	*20.6*	10.9	*12.2*	9.2	*7.5*	7.3	*2.6*	6.2	*4.5*	3.0	*1.8*	0.9	*0.0*	5.7	*12.1*	0.033	*7.7*
Moncton	10.4	*-14.3*	10.1	*-10.3*	12.5	*-7.7*	10.1	*-3.6*	8.3	*-2.7*	6.9	*-3.4*	3.1	*-1.7*	0.9	*-3.0*	7.2	*-14.4*	0.040	*-5.6*
Fredericton	13.8	*-4.7*	13.3	*-3.6*	16.6	*-0.7*	12.9	*0.2*	10.5	*2.5*	8.6	*0.3*	3.7	*2.2*	1.1	*0.0*	9.4	*-5.2*	0.050	*0.0*
La Malbaie	94.3	*4.9*	106.1	*4.6*	101.3	*2.3*	71.5	*0.8*	57.0	*1.8*	48.5	*1.9*	20.2	*1.6*	6.1	*4.0*	58.9	*4.8*	0.276	*1.8*
Quebec	24.3	*3.6*	23.8	*2.5*	24.3	*1.1*	19.1	*-2.7*	15.2	*2.2*	12.7	*3.2*	5.7	*0.5*	1.7	*-1.6*	16.4	*0.6*	0.071	*0.0*
Trois-Rivieres	26.6	*-9.8*	26.2	*-9.0*	25.6	*-7.2*	18.1	*-9.3*	13.7	*-7.1*	11.5	*-5.6*	4.5	*-8.1*	1.5	*-5.6*	18.1	*-9.6*	0.071	*-6.3*
Montreal	30.0	*-2.5*	29.4	*-2.5*	28.9	*-3.3*	20.5	*-1.0*	15.4	*-2.8*	12.9	*-0.6*	5.2	*-2.5*	1.6	*-3.4*	20.1	*-2.9*	0.079	*0.0*
Ottawa	28.8	*5.4*	28.6	*4.1*	27.7	*3.6*	20.0	*2.7*	14.8	*-0.5*	12.3	*2.2*	5.0	*-2.0*	1.5	*-5.4*	19.5	*5.9*	0.076	*3.2*
Niagara Falls	18.5	*5.7*	15.7	*0.6*	15.6	*1.2*	11.1	*2.9*	8.4	*0.3*	6.6	*-0.4*	2.7	*-1.9*	0.8	*0.0*	12.2	*5.8*	0.045	*-5.0*
Toronto	10.7	*3.4*	9.7	*4.0*	10.7	*-1.6*	8.3	*-0.3*	6.3	*-0.4*	5.0	*1.0*	2.2	*-1.2*	0.6	*0.0*	7.9	*10.7*	0.033	*0.0*
Windsor	5.8	*1.0*	5.8	*-3.5*	6.6	*-2.3*	5.1	*-2.1*	4.0	*0.6*	3.3	*0.7*	1.3	*-3.8*	0.4	*-6.7*	4.0	*-4.1*	0.021	*0.0*

	PSA 0.1 sec		PSA 0.15 s		PSA 0.2 sec		PSA 0.3 sec		PSA 0.4 sec		PSA 0.5 sec		PSA 1.0 sec		PSA 2.0 sec		PGA	
	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*	New value	*% change*
Calgary	4.2	*-1.0*	6.3	*3.7*	6.8	*2.0*	6.1	*5.9*	5.0	*8.0*	4.1	*-1.0*	2.0	*1.0*	1.1	*-2.6*	4.0	*0.3*
Kelowna	8.9	*-3.4*	12.5	*-0.5*	13.4	*-0.7*	11.9	*-1.5*	10.0	*-3.3*	8.5	*-0.2*	4.9	*4.4*	2.9	*-0.7*	7.1	*1.7*
Kamloops	8.8	*-3.6*	12.5	*-0.6*	13.3	*-0.5*	11.9	*-1.6*	9.9	*-3.6*	8.7	*-0.1*	5.4	*4.3*	3.2	*-0.3*	7.1	*2.0*
Prince George	3.5	*-5.5*	5.2	*-0.6*	5.7	*-0.4*	5.1	*0.2*	4.3	*0.0*	3.6	*-2.5*	2.1	*1.9*	1.4	*2.9*	3.3	*-4.9*
Vancouver	43.7	*5.6*	52.2	*12.1*	52.5	*6.0*	45.7	*4.6*	39.6	*3.0*	35.0	*1.1*	17.9	*3.7*	8.9	*0.0*	25.8	*1.8*
Victoria	59.1	*6.4*	68.6	*14.4*	67.8	*5.6*	57.7	*6.2*	49.8	*5.8*	44.6	*5.3*	20.3	*4.8*	9.6	*-0.9*	34.0	*0.8*
Tofino	20.2	*4.8*	27.5	*1.8*	29.3	*-0.2*	26.7	*1.5*	23.0	*3.1*	20.0	*3.7*	11.2	*2.1*	6.2	*1.8*	13.9	*5.1*
Prince Rupert	11.5	*-1.1*	16.4	*1.3*	17.6	*0.7*	16.2	*0.2*	14.3	*0.7*	12.9	*1.0*	8.8	*2.1*	5.1	*4.6*	9.2	*-1.2*
Queen Charlotte	28.3	*0.4*	38.8	*2.2*	42.7	*4.7*	41.9	*5.5*	38.7	*4.2*	35.5	*2.1*	23.9	*3.0*	13.0	*1.8*	22.0	*3.4*
Inuvik	3.1	*-4.1*	4.8	*-0.4*	5.4	*0.2*	5.3	*2.8*	4.6	*4.4*	4.0	*3.7*	2.3	*1.8*	1.5	*2.8*	3.2	*-3.1*

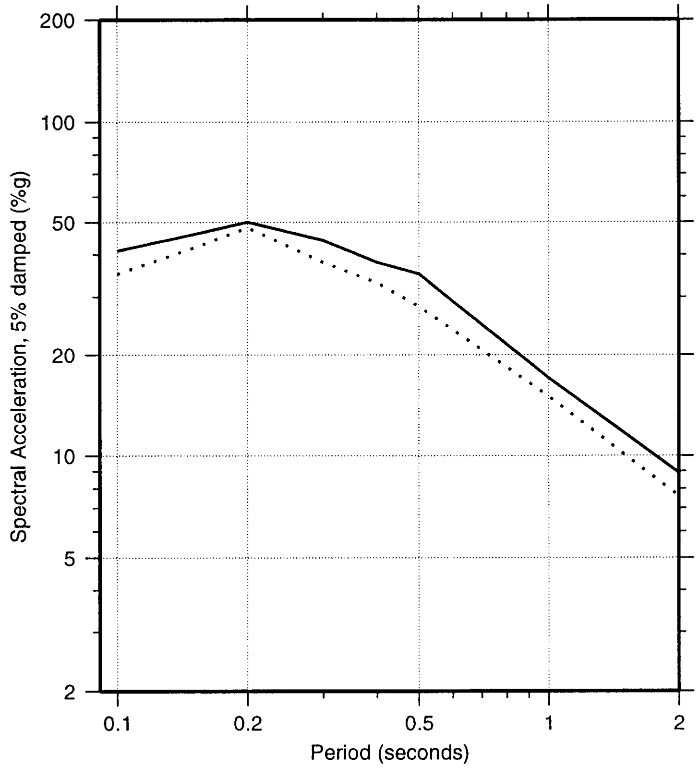


Figure A1.1 Vancouver "Robust" Uniform Hazard Spectra

APPENDIX A2

Summary of Changes between GSC Open File 3029 and GSC Open File 3283

Philosophy (by iteration between seismologists and engineers)
"Robust" combination approved by CANCEE.
Decision to use median (50th percentile) values adopted, so as to de-emphasize uncertainties.
Cascadia to be evaluated deterministically and combined with probabilistic values by "robust" method.

Source zones and Earthquake recurrence rates
Boothia-Ungava zone, northern Canada, replaced by 4 smaller zones in H model.
Some events in the Puget Sound / Strait of Georgia were reassigned from shallow to deep zones.
Magnitude-recurrence curve for crustal earthquakes in SW B.C. changed to accommodate history of large events (see figure 4 of the Open File).

SGM relations - East
No changes

SGM relations - West
Corrected errors in coefficients (b0+b6) for PSA0.2 for BJF relationship.
Corrected errors in PSA0.4 sigma values for Crouse relationship.
Smoothed Crouse's sigma values using a cubic relation.
Upper and lower attenuation relations for Crouse were set at a factor of 2 above and below the best relation to represent uncertainty consistent with treatment of BJF.
Crouse relations attributed to "soil", not "firm ground"; adjustments made.

Calculation program:
New subroutine to correct map projection at high latitudes.
Modified subroutine ATTEN in FRISK88 to "unbundle" the c1 ("constant") terms for western attenuations.

Blunders
Corrected values for St John's, Halifax and Moncton (PSA 0.3 and 0.5 s only) resulting from these three locations having been all shifted by one site.

APPENDIX A3

Justification for using the Youngs et al. (1997) relations for western subcrustal earthquakes

After reviewing the Youngs et al. (1997) paper, a comment (Fukushima (1997), and reply (Youngs, 1997), we feel that their relationship is better founded than that of Crouse (1991) used for subcrustal and subduction earthquakes in previous versions of the trial hazard calculations. Our reasons are as follows:

— Youngs et al. is based on a larger and better-selected data set, including data acquired subsequent to Crouse's study.

— The definition of distance in Youngs et al. is simpler to apply than Crouse's poorly-defined "center of energy release".

— The fall-off (attenuation) of ground motion with distance in Crouse is too slow relative to observations of Cordilleran attenuation derived by Atkinson (1997). The Youngs et al. relation has higher attenuation and gives ground motions for the subduction earthquake at 1000 km that are factors of 3 to 4 times lower than Crouse (Figs A3.1 and A3.2). Fukushima (1997) and Atkinson (1997) suggest even faster attenuation, but the former has been well answered by Youngs et al. (see below), and many of Atkinson's data points come from smaller and crustal events. Hence, her kappa may not apply. Our choice of Youngs et al. is likely to err on the conservative side.

— The Youngs et al. relationship has smooth variation of coefficients built into their treatment. This is preferable to our previous use of Crouse, where we found that coefficients among adjacent periods varied erratically, and we had to do our own smoothing of the coefficients before we could sensibly interpolate to provide hazard at periods not tabulated by Crouse. Our smoothing was not fully satisfactory, as judged by the roughness of the spectra calculated using Crouse (e.g. in GSC OF 3283, examine the spectra for Victoria, Fig. 23, at high frequencies).

— Youngs et al. provide a more consistent treatment of uncertainty, including smoothing with period.

— Youngs et al. find a significant and consistent difference between ground motions of interface (typically large subduction zone earthquakes involving shallow angle thrust events that occur between the subducting and overriding plates) and in-slab earthquakes (typically smaller earthquakes within the subducting slab that involve high-angle normal faulting; their term is "intraslab"). "The results of the regression analysis of the PGA data indicated that in-slab earthquakes produce peak motions that are on average about 50% higher than those for interface earthquakes for the same magnitude and distance" (Youngs et al., 1997, p. 66). Crouse stated that he could not distinguish between these events, so that when we used his relations for sites immediately above zones of in-slab earthquakes that dominate the hazard (e.g. Victoria and H events.

— The bias possible in all attenuation relations due to the selective triggering of instruments near their threshold has been raised by Fukushima (1997) and addressed (Youngs, 1997). [Only instruments that trigger provide records, so the non-triggered sites with lower than threshold motions do not enter into the analysis - this leads to a pulling-up of the best-fit curve for large distances, a flattening of the slope, and perhaps a reduced predictions at close-in distances]. Youngs et al. found no significant bias, either for the threshold suggested by Fukushima or when an even more severe threshold was applied.

— In Youngs et al., ground motion consistently increased with depth for all periods, while for Crouse there is a decrease at the longest periods.

— We note also that the USGS are currently using Youngs et al., not Crouse, in their hazard work.

As described above, Youngs et al. differentiates between subduction zone interface and in-slab earthquakes. The Cascadia event would be an interface earthquake while the deep events in Puget Sound are considered in-slab. Youngs et al. account for this with an "on/off" switch parameter of 0.3846*Zt, with Zt=0 for interface, 1 for in-slab earthquakes (exp(0.3846) = 1.47, i.e., 47% larger than for interface events). Therefore effectively we will be using two different relations: the in-slab relation in the H and R probabilistic models; and the interface relation for the Cascadia event.

Ground condition factors. Youngs et al. (p. 59) state their "rock" site conditions are considered to be consistent with Boore et al. site class A/B boundary (750 m/s). To convert to our soil class B (555 m/s), we multiplied through by the impedance contrast, sqrt(750/555) = 1.162. This neglects the density effects but should be sufficiently accurate. In the hazard formula, the natural log of this is added to the result.

References for this Appendix

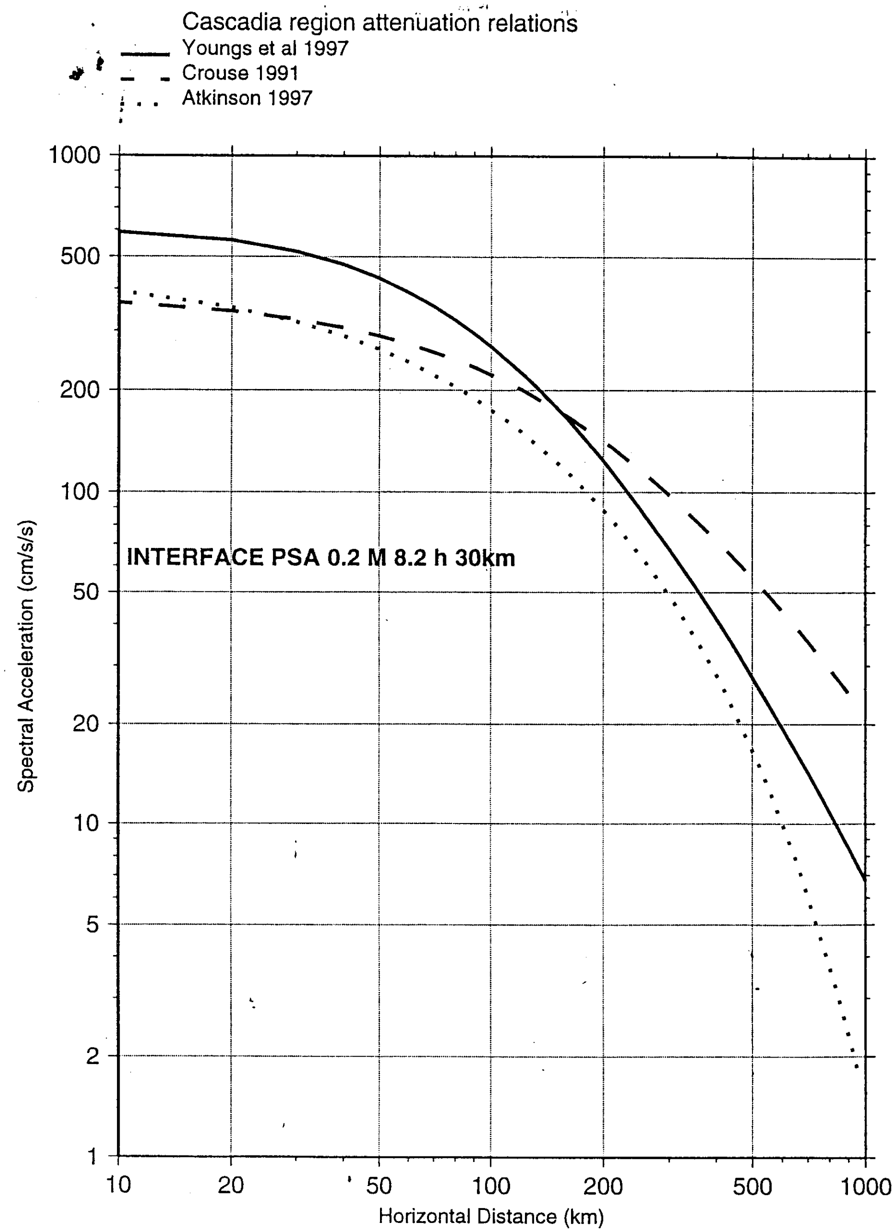
Atkinson, G.M. 1997. Empirical ground motion relations for earthquakes in the Cascadia region. Canadian Journal of Civil Engineering vol 24, p. 64-77.

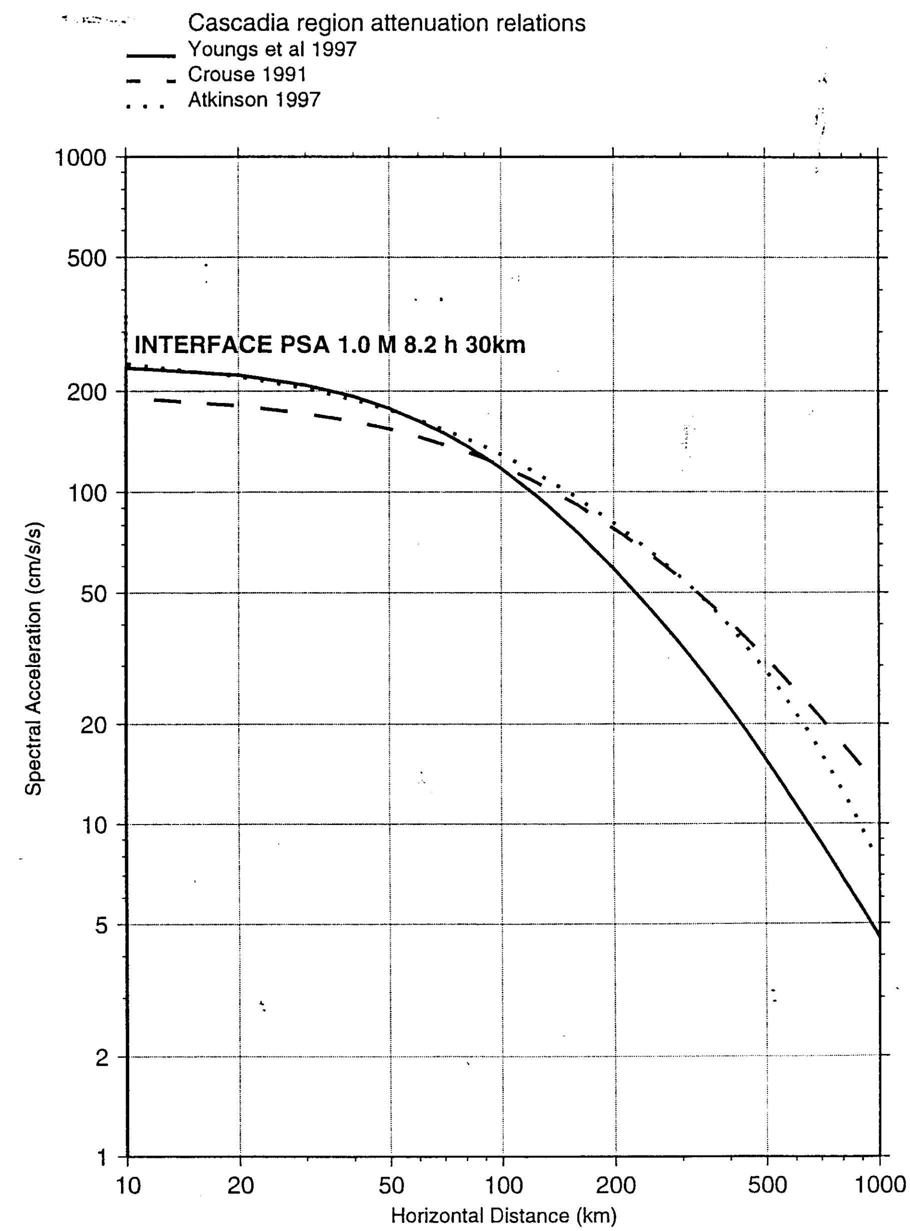
Crouse, C.B. 1991. Ground-motion attenuation equations for Cascadia subduction zone earthquakes. Earthquake Spectra vol 7, p. 201-236.

Fukushima, Y., 1997. Comment on "Ground Motion Attenuation Relations for Subduction Zones". Seismological Research Letters, Vol 68, No 6. p. 947-949.

Youngs, R.R., 1997. Reply to comment by Y. Fukushima. Seismological Research Letters, Vol 68, No 6. p. 950-951.

Youngs, R.R., Chiou, S.-J., Silva, W.J., Humphrey, J.,R. 1997. Strong Ground Motion Relationships for Subduction Zone Earthquakes. Seismological Research Letters, Vol 68, No 1. p. 58-73.


Cascadia region attenuation relations
Youngs et al 1997
Crouse 1991
Atkinson 1997
INTERFACE PSA 0.2 M 8.2 h 30km
Spectral Acceleration (cm/s/s)
Horizontal Distance (km)
1000
500
200
100
50
20
10
5
2
1
10
20
50
100
200
500
1000


Cascadia region attenuation relations
Youngs et al 1997
Crouse 1991
Atkinson 1997
INTERFACE PSA 1.0 M 8.2 h 30km
Spectral Acceleration (cm/s/s)
Horizontal Distance (km)
1000
500
200
100
50
20
10
5
2
1
10
20
50
100
200
500
1000

APPENDIX A4

Rationale for using the 2%/50 year probability level hazard results

Current practice, in Canada and other countries, has been to use probabilistic seismic hazard calculated at the 10%/50 year level for seismic design provisions. The performance of those design provisions, as deduced from global engineering experience with buildings in earthquakes, appears much better that the probability level used would suggest. Heidebrecht (1999) suggests the 2%/50 year probability level represents the approximate structural failure rate deemed acceptable.

A "hazard curve" can be used to display how ground shaking changes as a function of probability for a given shaking parameter. From the seismic hazard model used in this report we computed the hazard curves for Montreal and Vancouver for PSA0.2 sec (Fig. A4-1). Although not shown on the figure, the uncertainties become larger as the probability level drops. Two special points on the curve correspond to probabilities of 10%/50 years (0.0021 p.a.) and 2%/50 years (0.0004 p.a.). In this range of probabilities the hazard curve for Montreal has a steeper increase in expected ground motions with decreasing probability than for Vancouver, with the 2%/10% ratio being 2.35 for Montreal but 1.94 for Vancouver. The slopes of each city's hazard curve are a function of the size and distance distribution of earthquakes contributing hazard to each city. In general, where sites are dominated by distant, high-activity zones (in which earthquakes near the upper bound are relatively common), the hazard curve is less steep (= low ratio) than for sites that lie within moderate seismicity zones. While average values for the 2%/10% ratios for east and west cities are approximately 2.34 and 1.91 (Adams et al., 1999), they vary considerably, as shown also by their spatial variation.

The variation means that applying a national, or even regional multiplicative factor to the 10%/50 year values will not reproduce lower probability hazard values reliably. The very different average slopes between east and west have important consequences for safe design. For example, the annotations on Fig. A4-1 show the effect of applying a constant factor of two (say, a "experiental factor of safety" term) to both the Vancouver and Montreal 10%/50 values. For Vancouver this would give a design appropriate to 1/2400 year shaking, but for Montreal a design appropriate to 1/1600 year shaking. Clearly the same level of safety has not been achieved. Even if different constants were used for east and west, the geographical variation shown in Fig. A4-2 (and present across all of Canada) would preclude achieving a constant level of safety by this means.

We conclude that the direct calculation of seismic hazard at the probability level most appropriate for design is necessary. Therefore the 2%/50 year seismic hazard values we present can help to achieve an improved, uniform level of safety.

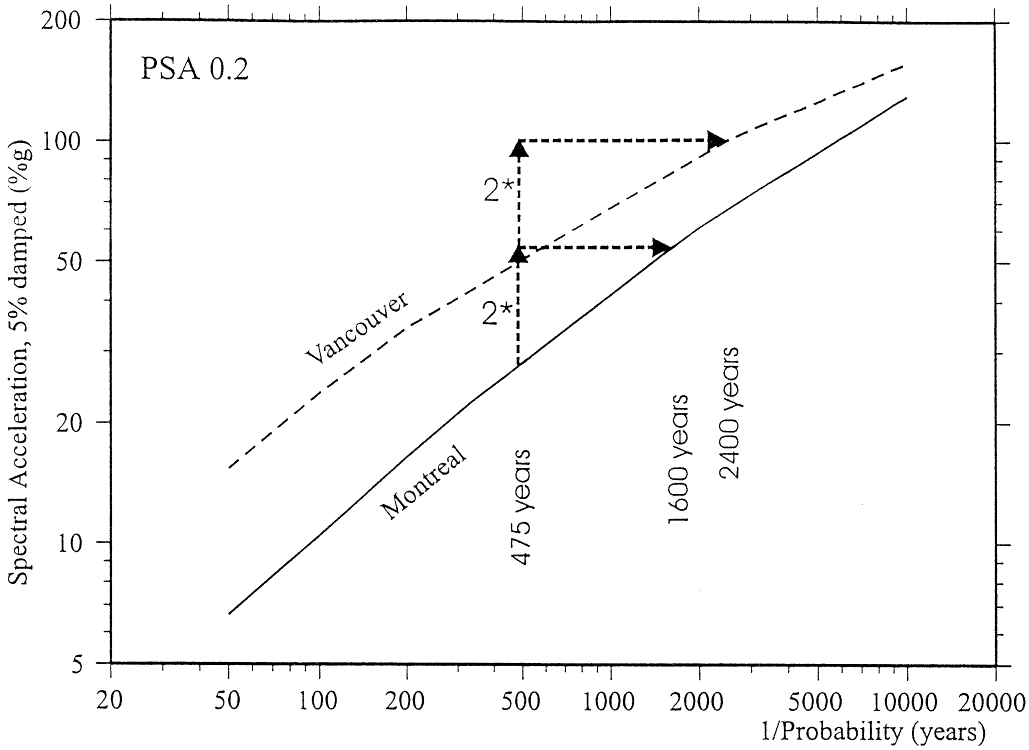


Figure 2. PSA0.2 hazard curves for Vancouver and Montreal, showing how increasing the 10%/50 year hazard by a factor of two produces different increases in safety.

A4-1

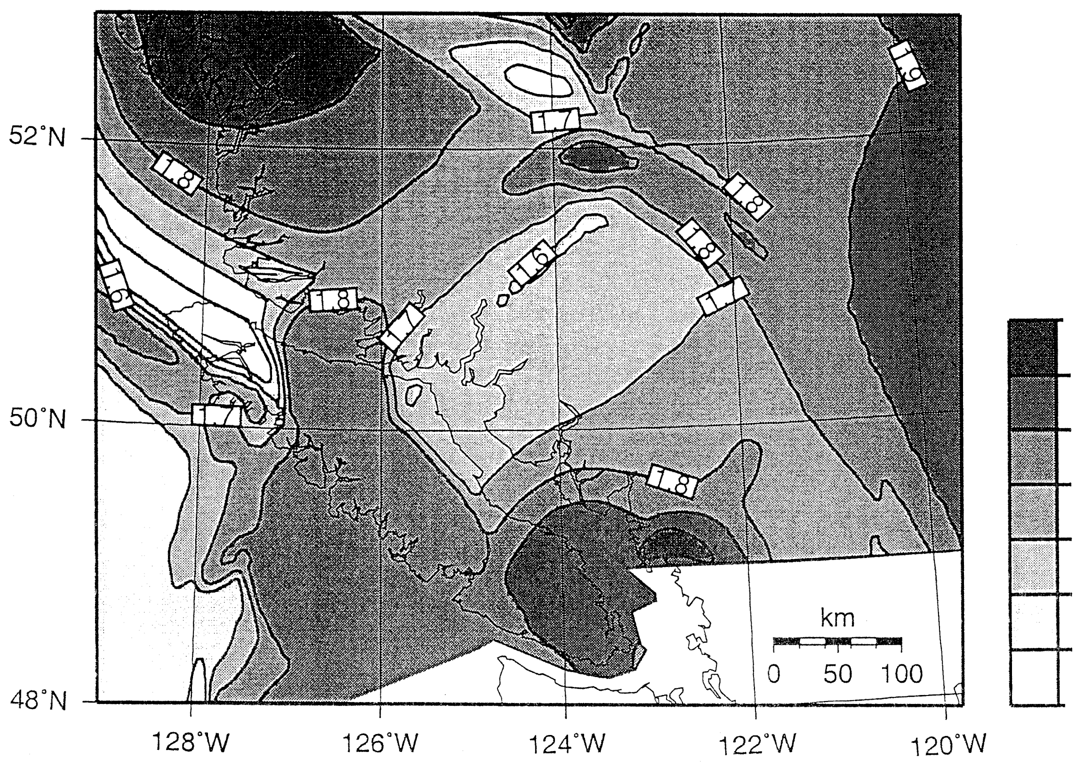


Figure 3. Ratio of 2%/50 year to 10%/50 year PSA0.2 hazard for southwestern B.C.

A4-2

APPENDIX B

Alternative approaches for computing RGCs.

This appendix reproduces text from GSC Open File 3283 with regard to alternative approaches to computing RGCs.

An Alternative Approach

Since the issue of GSCOF3029, there has been some concern expressed that the Class Ao represented rock with velocities much lower than those of the seismometer sites in eastern Canada, and hence that the amount of amplification from rock to firm ground was being underestimated.

After discussions with Gail Atkinson it seems that an appropriate choice for the near-surface shear wave velocity is 2800 m/s for eastern hard rock. California rock (Martin and Dobry Class A) might be taken as 1050 m/s, the average of Borcherdt's shear velocity range for California SC-1b (Borcherdt, ATC 35-1) or 1130 m/s from NEHRP's class B rock. For the former, Martin and Dobry's 0.8 factor would have de-amplified Class B soil to 1640 m/s rock, and an additional factor of 0.76 would have been needed to match the extra impedance contrast of eastern hard rock. However the regression results in BJF94, and the analysis below both indicate that the data suggest ≈1750 (range 1100 to 2200) m/s for the Class A reference rock velocity (assuming that the BJF's VA parameter has physical meaning).

In the BJF94 characterization of site velocities the terms "b6*Gb +b7*Gc" in their 1993 formulation are replaced by the term:

$$BV(\log VS - \log VA)$$

where BV and VA are empirical coefficients (given in BJF94, Table 2), VS is the time-weighted average shear-wave velocity to 30 m depth for the site, and VA can be thought of as the reference rock condition (since when VS = VA the "soil" term vanishes),

Then, for example, for 5% damped 0.5 sec motions:

BV= −0.553, VA=1780 (BJF94, Table 2)
VS=2800 ("eastern hard-rock" - our assumption)
coefficient (hard rock → VA) = 0.109 log units

[This assumes that the behaviour of waves in rock with velocities above ≈1800 m/s is better obtained by extrapolation from relations in slower rock than by direct computation of impedance.]

and

BV= −0.553, VA=1780 (BJF94 Table 2)
VS=555 (average of range of velocity for definition of class B)

coefficient (VA → soil B) = 0.280 log units

Hence, hard-rock to class B = 0.109 + 0.280 = 0.389 log units
amplification factor (hard rock → class B) = 2.45
(compare to GSCOF3029 RGC factor of 2.38)

We have broken out the calculation into a two-stage process purposefully, and chosen 0.5 s as a representative parameter. Comparison with the 0.5 s values in GSCOF3029 Table 1 suggest that in the new formulation the "hard-rock → class B" coefficient for 0.5 s replicates the B6 value (BJF93) <u>and</u> the "hard rock → VA" replicates the Martin and Dobry "0.8" value (of 0.097 log units) very well.

Note that the physical meaning of the VA parameter is rather uncertain because:
(1) together, the parameters BV and VA must include (a) density change effects, since conservation of energy involves impedance contrast, not just the seismic velocities; (b) any non-linear effects in class B soil; and (c) "skin" effects (through the 1/4 wavelength effect?), perhaps accounting for some of the decrease in VA for periods less than 0.2 sec;
(2) there may well be non-physical (statistical) trade-offs between VA and the parameter BV; and
(3) the VA parameter varies somewhat with damping.

Now, regardless of the exact meaning of VA, we could use the BJF94 formulation directly to get "Class B → 2.8 km/s rock" coefficients through:

coefficient (hard rock → class B) = BV[log (555) − log (2800)] = −0.703*BV

which depends only on the assumed average velocity of soil B and of eastern hard rock, and the coefficients BV (see Table 2).

The new values are similar to the GSCOF3029 RGC factors for periods except 1.0 s, for which the VA values are discrepant (examine column 2 of Table 2) and rather smaller (1410 m/s) than for the rest of the periods we use (range 1780-2130 m/s). If we accept the above approach, it seems that the consensus of Martin and Dobry of 1/0.8 = 1.25 for hard rock indeed accommodates our eastern hard rock (for T=0.5, VA=1780 m/s, VS=2800 for hard rock, the square-root relationship, neglecting density, gives 1.254).

A Second Alternative approach

A different approach could be used, accepting the Class B → VA amplification factors directly from BJF94 and then adjusting from the BJF VA value to 2800 m/s rock. Atkinson *(submitted, 1995)*, made the adjustment by using the square-root of the velocity ratio, 2800/VA, as an approximation, but this neglects the density contrast. In Table 2 we show RGC factors calculated by the impedance method using estimated densities.

The RGC estimates in Table 2 are quite similar among the three approaches for periods 0.15-0.5

s and 2.0 s (Fig. 4), and confirm the robustness of the simple approach taken to derive the RGC factors in GSCOF3029. The difference at 1.0 sec (the largest RGC estimate is 20% larger than smallest), is of concern, but occurs where BJF94's VA values are in a low between values of >1750 m/s at both shorter and longer periods. The major discrepancy at the 0.1 s period seems to be directly related to the very low VA (VA falls rapidly from 1720 m/s at 0.14 to 1110 m/s at 0.1 s in BJF94) used in the impedance method. The large value of RGC computed by the impedance approach may not be physically realistic, because ground motions at higher frequencies are normally considered to be weakly amplified or even attenuated on soft ground.

Table B.1

Comparison of Reference Ground Condition Factors computed by alternative approaches

Period	BV	VA	C5	RGC	B←VA	VA←EHR	C5	RGC	RGC
(s)	log10	m/s	log10	BJF	...log10 units..			Imped.	Table 1
Notes→	1	2	3	4	5	6	7	8	9
0.1	-0.212	1110	0.149	1.41	0.064	0.245	0.309	2.04	1.39
0.15	-0.238	1820	0.167	1.47	0.123	0.110	0.233	1.71	1.73
0.2	-0.292	2120	0.205	1.60	0.170	0.069	0.239	1.73	1.94
0.3	-0.401	2130	0.281	1.91	0.234	0.068	0.302	2.00	2.17
0.4	-0.487	1950	0.342	2.20	0.266	0.087	0.353	2.25	2.30
0.5	-0.553	1780	0.389	2.45	0.280	0.111	0.391	2.46	2.38
1.0	-0.698	1410	0.491	3.09	0.283	0.175	0.458	2.87	2.58
2.0	-0.655	1790	0.460	2.89	0.333	0.110	0.443	2.77	2.86
PGA	-0.212	1110	0.149	1.41	0.064	0.245	0.309	2.04	1.39
PGV	-0.553	1780	0.389	2.45	0.280	0.111	0.391	2.46	2.38

General Notes

A. Columns C5 contain the calculated coefficients (in log10 units) that might be used for Class B soil with Atkinson's (1995a) S parameter.

B. The RGC (Reference Ground Condition) factors represent the C5 values as a multiplicative factor, and might be used to modify eastern hard rock hazard values to those expected on the reference ground condition of "Class B" soil.

C. RGC factors for PGA and PGV were assigned by associating them with periods of 0.1 s and 0.5 s., respectively.

D. An excess of digits is carried in this table to show the derivation of the factors. Final factors should be represented to 2 significant figures (e.g. 2.4). The guess made for the velocity of eastern hard rock results in a ≈5% uncertainty in the multiplicative factors.

Column Head Notes:

1. Column BV is taken from Boore-Joyner-Fumal (1994) Table 2, "random 05%" column.

2. Column VA is taken from Boore-Joyner-Fumal (1994) Table 2, "random 05%" column.
3. Column C5 (in log10 units) is calculated from −0.703*BV.
4. The RGC factor represents the C5 value as a multiplicative factor.
5. B←VA calculated using VB=555 m/s.
6. VA←EHR (Eastern Hard Rock) using log10(sqrt[(2800*2.7)/(VA*densityVA)]) where densityVA is taken to be values like: 2.2 g/cm^3 for ≈1100 m/s, 2.4 for 1400, 2.6 for 2000, and 2.7 for 2800.
7. Column C5 (in log10 units) is calculated from the sum of B→VA and VA→EHR columns.
8. The RGC factor represents the C5 value as a multiplicative factor.
9. This RGC column represents the values in GSCOF3029 (see Table 1).

APPENDIX C

The 1995 Seismicity models for Probabilistic Hazard

Contents: Background Information on the Zone Parameters in the Parameter Tables
Tables of the seismic source zone parameters
Maps of the seismic source zones for **H** and **R** models:
Canada, Eastern Canada, Western Canada, Shallow/deep zones in SW B.C.

Background Information on the Zone Parameters in the Parameter Tables

Source Models. For four models —eastern **H** and **R**, and western **H** and **R** —zone parameters are tabulated separately (zone corner coordinates are available in Appendix D). By using the code FRISKGSC (which is the front-end for a slightly custom-tailored version of the commercial hazard code FRISK88 of Risk Engineering Inc.) we can incorporate a range for some of the input parameters so as to include multiple hypotheses and compute a degree of uncertainty in the resultant hazard calculations. Some zones are common to more than one model (see table) and where practical the common parameters and ranges of parameters have been kept consistent.

Magnitude Recurrence. Three estimates, weighted 0.68, 0.16, and 0.16, are used. The heavily-weighted "best" represents the Maximum Likelihood fit using essentially the modification of the maximum likelihood method suggested by Weichert (1980), the same method as used for the last seismic hazard mapping project, as described by Basham et al. (1985).

Earthquakes with epicentres within the source zones of the two alternate models are selected from the appropriate Earthquake Epicentre File. Magnitude intervals of 0.1 magnitude units were used; for zones with events spanning only a short magnitude range this should result in a better definition of the recurrence slope, since grouping into half-magnitude intervals would irrevocably discard information. The magnitude uncertainty of a single event is nevertheless still on the order of 1/4. No explicit correction for this has been attempted.

A reliability factor for the eastern zones (# EVTS) is the total number of events above the lower completeness threshold, usually around magnitude 2.8 to 4.0. Since the FRISK88 program expects the activity rate at zero-magnitude, N0, as a parameter, this is listed, but we note that it is strongly dependent on the slope, "BETA". We have also reported it to an undue level of precision. Also listed is the activity near the damage threshold, "BEST N5". This parameter is much less dependent on the BETA estimate than N0 (which is obtained by extrapolation), and is far more representative of the rate of earthquakes which contribute significant ground motions. The value "Mag 5 Rate/Area" normalizes the activity to the source zone size to allow comparison between zones.

Conservative estimates for the "LOWER" and "UPPER" magnitude-recurrence curves are obtained by curves anchored to points one standard deviation above and below the total number of observed events at the magnitude threshold, and having slope parameters one standard deviation shallower and steeper than the central value. This corresponds to a full standard deviation for each variable (instead of the more usual root-mean-square), but the increase is small for most data sets because at the magnitude threshold the uncertainty in the cumulative rate is generally low.

An examination of recurrence slopes in adjacent source zones showed that the recurrence slope could be averaged over several zones, and the activity then fitted under the constraint of a common slope. This procedure is useful for source zones with inadequate data for independently fitting both recurrence parameters. In the east, the recurrence slope derived from a larger source zone (say IRM) was sometimes imposed on smaller zones contained therein (e.g. TIM); it is flagged by an 'F' in the parameter table.

The three corresponding activity-recurrence slope pairs and the three maximum magnitude estimates are specified for input to FRISK88; a program switch specifies that these parameters are treated as 'perfectly dependent'. This appears reasonable since they are calculated in a dependent manner.

Maximum Magnitude: Estimates of upper-bound magnitude were made for each source zone on the basis of observed largest earthquake, tectonic judgement, or simply in a conservative fashion, remembering that the Nahanni and Saguenay earthquakes both exceeded the maximum earthquake specifications for their respective source regions within 10 years of preparation of the 1985 maps. For each zone, three estimates were used and fitted with a slope and recurrence. While the activity rate is dominated by the total number of events observed above the lower threshold, properly weighted according to their period of observation, the recurrence slope is more strongly affected by the chosen upper-bound magnitude. In anticipation of using these upper-bound magnitude estimates as input to FRISK88, two points of view were considered in choosing the three trial values. FRISK88 allows only one common set of weights to be applied to the alternate choices of parameter sets in a given model. This would imply that the three upper-bound magnitudes should be representative of the same percentile of the upper-bound magnitude distribution for each source zone. Often it *feels* best, to space the estimates evenly, suggestive of symmetric distributions, but this may lead to unreasonably high maximum upper-bound magnitudes, because that value is pushed up by an observed, but possibly incorrect magnitude. This scenario would justify unequal spacing of the upper-bound magnitude estimates. Similarly, some regions may have quite well-established upper-bound magnitudes, because of high activity with a sharp cutoff, supported by a knowledge of maximum fault areas in the source zone; in this case the upper two upper-bound magnitude estimates may also justifiably be set closer together. These considerations have led to slightly different weightings for the LOWER-BEST-UPPER upper-bound magnitude: 0.3-0.6-0.1 for the east and 0.16-0.68-0.16 for the west.

Depth: For the east, best depths and upper and lower bounds are intended to indicate the likely range of earthquake depths. However in order to assign appropriate weights to the various values, for some zones (e.g. SGL), the terms lower and upper refer merely to alternative values, not relative depths. The weights are 0.5, 0.25, and 0.25.

Depth values in the western zones where the BJF relations are used (shallow crustal zones) have no physical meaning in the hazard calculation, despite our knowledge of earthquake depths there. Instead the value is a parameter in the Boore et al. (1993, 1994) equations and its value depends on the period for which ground motions are being estimated. For the subcrustal in-plate zones, for which the Youngs et al. relation is used, we decided on a single depth of 50 km near the depths of the large earthquakes that presumably occur at or near the change of subduction angle of the Juan de Fuca plate.

1994 H MODEL ZONE PARAMETERS

EASTERN CANADA

ZONE	Mag 5 Rate/Area (x 10^-6)	BEST BETA	BEST N0	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA (sq. km)	EVTS
WEIGHTS		0.68		0.16		0.16			0.6	0.3	0.1	0.5	0.25	0.25		
Southeastern Canada																
ADR	0.454	1.84	142	2.19	291	1.50	60	0.0138	7.0	6.0	7.5	10	20	5	30400	20
AOH	1.90	2.05F	575	2.15	402	1.95	700	0.0200	7.0	6.0	7.5	5	20	5	10500	7
BSL	2.09	1.93	533	2.13	781	1.74	344	0.0335	7.5	6.0	7.7	10	20	5	16000	58
CHA	0.417	2.00F	107	2.10	92	1.90	120	0.0048	7.5	6.0	7.7	10	20	5	11500	7
CHV	13.2	1.74	374	1.85	477	1.62	310	0.0625	7.5	7.2	7.7	10	20	5	4740	100
COC	0.110	2.00F	76	2.10	74	1.90	126	0.0034	7.5	6.0	7.7	10	20	5	31000	5
GAT	1.17	2.07	1190	2.23	1580	1.91	811	0.0378	7.0	6.5	7.5	10	20	5	32300	97
GNS	0.283	2.00F	237	2.10	248	1.90	223	0.0107	7.5	6.0	7.7	10	20	5	37800	21
JMS	0.0545	2.00F	167	2.10	190	1.90	237	0.0072	6.5	6.0	6.7	10	20	5	132000	9
MNT	0.986	1.96	258	2.19	405	1.74	167	0.0140	7.5	6.5	7.7	10	20	5	14200	35
NAN	0.231	1.75	374	1.90	508	1.60	276	0.0573	7.0	6.0	7.0	5	20	5	248000	79
NAT	0.568	1.80	69	2.23	164	1.37	29	0.0083	7.0	6.0	7.5	5	20	5	14600	11
OBGH	0.0216	2.00F	273	2.20	346	1.80	176	0.0118	6.5	6.0	6.7	5	20	10	547000	23
PEM	0.293	1.95	140	2.34	271	1.57	55	0.0080	7.5	6.0	7.7	10	20	5	27300	16
PMQ	1.26	1.72	49	2.17	124	1.26	18	0.0089	7.0	6.5	7.5	10	20	5	7050	9
SAG	0.328	2.00F	89	2.10	67	1.90	84	0.0040	7.5	6.5	7.7	10	30	5	12200	9
SEB	0.0310	2.00F	649	3.33	25400	1.80	532	0.0289	7.0	6.0	7.5	10	20	5	932000	35
SLE	0.403	2.09	169	2.57	457	1.61	61	0.0048	7.0	6.0	7.5	5	20	5	11900	11
TAD	-	-	-	-	-	-	-	-		as TRR			as TRR		5780	0
TIM	0.763	2.00F	63	2.10	47	1.90	65	0.0029	7.5	6.5	7.7	10	20	5	3800	8
TRR	0.279	2.00F	113	2.10	113	1.90	122	0.0051	7.5	6.0	7.7	10	20	5	18300	11
Arctic Canada																
DIB	0.0945	2.25F	1200	2.55	2330	1.95	600	0.0154	7.0	6.0	7.5	10	20	5	163000	7
GLA94	4.25	1.54	206	1.90	597	1.18	65	0.0884	7.0	6.5	7.5	10	30	5	20800	18
QES	0.862	2.00F	1175	2.25	2310	1.75	570	0.0530	7.33	6.29	7.63	10	20	5	61500	18
									7.5	6.0	8.0[1]					
RST	0.289	2.00F	914	2.28	1920	1.72	406	0.0408	7.0	6.5	7.5	10	20	5	141000	14
SPB	0.109	2.00F	374	2.20	478	1.34	88	0.0167	7.0	6.5	7.5	10	20	5	153000	6
SVD94H	0.207	2.25F	6330	2.55	16300	1.95	2390	0.0814	7.0	6.5	7.5	10	20	5	393000	37
UNG	0.128	2.00F	849	2.28	1700	1.24	60	0.0378	7.0	6.5	7.5	10	20	5	296000	13
WGB	0.380	2.00F	737	2.28	1470	1.72	366	0.0328	7.0	6.5	7.5	10	20	5	86300	11
Eastern Continental Margin																
AOBH	0.0381	2.00F	755	2.20	1530	1.80	927	0.0340	7.5	6.0	7.5	10	20	5	893000	5
BFB	1.04	1.64	884	1.84	1570	1.45	485	0.233	7.5	7.3	8.0	10	20	5	224000	53
BIN	1.83	1.92F	1730	2.09	2440	1.75	1000	0.114	7.0	6.5	7.5	5	20	10	62200	69
BIS	0.644	1.92F	558	2.09	705	1.75	351	0.0370	7.0	6.0	7.5	5	20	10	57500	22
GLD	0.326	1.70F	500	3.11	78300	1.50	285	0.100	7.33	7.0	7.63	10	20	5	307000	23
									7.5	7.0	8.0[1]					
LBR	1.64	2.00F	3970	2.46	21900	1.90	3210	0.171	6.66	6.29	7.33	10	20	5	104000	34
									6.5	6.0	7.5[1]					
LBS	0.733	1.70F	358	2.61	11100	1.50	225	0.0718	7.33	6.66	7.63	10	20	5	98000	12
									7.5	6.5	8.0[1]					
LSP94	4.13	1.70F	278	1.90	404	1.44	140	0.0558	7.33	7.33	7.63	10	20	5	13500	18
									7.5	7.5	8.0[1]					

1994 R MODEL ZONE PARAMETERS

ZONE	Mag 5 Rate/Area	BEST BETA	BEST N0	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA	EVTS
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.6	0.3	0.1	0.5	0.25	0.25	(sq. km)	
Southeastern Canada																
ADR	0.454	1.84	142	2.19	291	1.50	60	0.0138	7.0	6.0	7.5	10	20	5	30400	20
CMF	0.122	2.02	425	2.27	696	1.78	247	0.0169	7.0	6.5	7.5	10	20	5	138000	40
COC	0.111	2.00F	76	2.10	74	1.90	126	0.00345	7.5	6.0	7.7	10	20	5	31000	5
GAT	1.17	2.07	1190	2.23	1580	1.91	811	0.0378	7.0	6.5	7.5	10	20	5	32300	97
IRB	0.0301	2.00F	630	2.10	844	1.90	688	0.0281	7.0	6.0	7.5	10	20	5	932000	34
IRM	0.942	1.98	2220	2.07	2720	1.88	1810	0.113	7.5	7.2	7.7	10	20	5	120000	215
JMS	0.0545	2.00F	167	2.10	190	1.90	237	0.00720	6.5	6.0	6.7	10	20	5	132000	9
LAB	0.101	2.00F	155	2.10	131	1.90	164	0.00699	7.5	6.0	7.7	10	20	5	69300	9
NAI	0.366	1.51	111	1.68	152	1.33	79	0.0567	7.0	6.0	7.0	5	20	5	155000	49
OBGR	0.0114	2.00F	144	2.20	156	1.80	100	0.00621	6.5	6.0	6.7	5	20	10	547000	10
SGL	0.121	1.99	454	2.23	724	1.75	262	0.0212	7.0	6.0	7.5	5	20	10	175000	40
Arctic Canada																
ACM	0.461	2.08	5100	2.34	11600	1.83	2250	0.152	7.33	7.0	7.63	10	20	5	330000	57
									7.5	7.0	8.0[1]					
BOU94	0.129	2.02	3150	2.30	7730	1.74	1250	0.128	7.0	6.5	7.5	10	20	5	989000	45
DIB	0.0945	2.25F	1200	2.55	2330	1.95	600	0.0154	7.0	6.0	7.5	10	20	5	163000	7
SVD94R	0.303	2.25	9170	2.53	23000	1.96	3590	0.119	7.0	6.5	7.5	10	20	5	393000	55
Eastern Continetal Margin																
AOBR	0.0472	2.00	587	2.20	873	1.80	514	0.0261	7.0	6.0	7.5	10	20	5	553000	9
BFI	0.540	1.92	2390	2.09	3490	1.74	1380	0.160	7.0	6.5	7.5	5	20	10	300000	96
ECM	0.434	1.70F	1840	1.90	3460	1.50	956	0.368	7.33	7.20	7.63	10	20	5	848000	89
									7.5	7.3	8.0[1]					
GLD	0.326	1.70F	500	3.11	78300	1.50	285	0.100	7.33	7.0	7.63	10	20	5	307000	23
									7.5	7.0	8.0[1]					
LBR	1.63	2.00F	3970	2.46	21900	1.90	3210	0.171	6.66	6.29	7.33	10	20	5	105000	34
									6.5	6.0	7.5[1]					

1994 R MODEL ZONE PARAMETERS

REGION: WESTERN CANADA

ZONE	Mag 5	BEST		LOWER		UPPER		BEST	MX			DEPTH			APPROX.
	Rate/Area	BETA	N0	BETA	NO	BETA	NO	N5	BEST	LOWER	UPPER	BEST	LOWER	UPPER	AREA
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.68	0.16	0.16	1.0	0.0	0.0	(sq. km)
ALC	21.4	1.43	3848	1.51	5731	1.35	2585	3.00	8.5	8.2	8.7	2.9-7.2	0	0	140000
ALI	29.0	1.73	57235	1.84	99129	1.62	33058	10.0	8.5	8.2	8.5	2.9-7.2	0	0	344000
BFT	1.90	1.69	622	1.86	853	1.52	393	0.126	7.0	6.7	7.3	2.9-7.2	0	0	66300
BRO	36.2	1.06	8	1.26	8	0.86	6	0.0347	7.0	6.7	7.3	2.9-7.2	0	0	960
CAS	1.12	0.85	14	1.86	1222	0.85	14	0.188	7.7	7.7	7.7	2.9-7.2	0	0	166000
CST	0.481	1.55	317	1.76	563	1.34	177	0.133	7.5	7.4	7.6	2.9-7.2	0	0	275000
DEN	4.50	1.87	3903	1.96	4836	1.78	3182	0.334	7.0	6.7	7.3	2.9-7.2	0	0	74200
EXP	11.4	1.30	103	1.45	160	1.15	85	0.143	7.0	6.7	7.3	2.9-7.2	0	0	12500
FHL	2.33	2.49	14016	2.93	63130	2.06	3021	0.0546	7.3	7.1	7.5	2.9-7.2	0	0	23400
GOA	15.7	2.31	49696	2.47	86255	2.15	28865	0.472	7.8	7.6	8.0	2.9-7.2	0	0	30100
GSP	2.70	1.12	29	1.25	35	0.99	25	0.0974	7.1	6.9	7.3	50	0	0	36000
HEC	1.76	1.97	1187	2.06	1358	1.87	1088	0.0626	7.0	6.7	7.3	2.9-7.2	0	0	35500
JDFF	0.368	1.87	91	2.26	175	1.48	42	0.0079	7.0	6.7	7.3	2.9-7.2	0	0	21300
JDFN	0.219	2.07	109	2.58	264	1.56	39	0.0035	7.1	6.7	7.3	2.9-7.2	0	0	15900
MMB	1.42	2.43	58008	2.50	72700	2.35	49997	0.307	7.1	6.9	7.3	2.9-7.2	0	0	216000
NBC	0.008	3.20	22787	3.73	67166	2.67	4205	0.0025	6.0	5.7	6.3	2.9-7.2	0	0	314000
NOF	8.53	1.73	458	1.82	522	1.64	428	0.0778	7.0	6.7	7.3	2.9-7.2	0	0	9110
NYK	0.193	3.75	7080982	4.35	70270912	3.15	697501	0.0508	7.0	6.7	7.3	2.9-7.2	0	0	262000
OFS	20.5	2.10	46683	2.22	73246	1.98	30343	1.26	7.1	6.9	7.3	2.9-7.2	0	0	61700
QCF	10.9	1.55	1529	1.61	1829	1.48	1387	0.671	8.5	8.2	8.5	2.9-7.2	0	0	64600[1]
RMN	6.72	2.00	2918	2.14	3948	1.86	2016	0.131	7.0	6.7	7.3	2.9-7.2	0	0	19400
RMS	13.6	1.67	1248	1.78	1540	1.56	945	0.287	7.0	6.7	7.3	2.9-7.2	0	0	21000
ROC	0.251	2.04	1560	2.25	2557	1.82	883	0.0582	7.0	6.7	7.3	2.9-7.2	0	0	232000
SBC	0.117	2.21	1384	2.49	2787	1.92	673	0.0219	7.0	6.7	7.3	2.9-7.2	0	0	186000
SOY	0.134	2.15	1690	2.42	3157	1.87	853	0.0362	7.0	6.7	7.3	2.9-7.2	0	0	270000
YAK	5.93	2.01	16307	2.07	18689	1.95	14305	0.705	8.5	8.2	8.7	2.9-7.2	0	0	118000

1994 H MODEL ZONE PARAMETERS

REGION:	WESTERN CANADA														
ZONE	Mag 5 Rate/Area	BEST BETA	BEST NO	LOWER BETA	LOWER NO	UPPER BETA	UPPER NO	BEST N5	MX BEST	MX LOWER	MX UPPER	DEPTH BEST	DEPTH LOWER	DEPTH UPPER	APPROX. AREA
WEIGHTS	(x 10^-6)	0.68		0.16		0.16			0.68	0.16	0.16	1.0	0.0	0.0	(sq. km)
ALC	21.4	1.43	3848	1.51	5731	1.35	2585	3.00	8.5	8.2	8.7	2.9-7.2	0	0	140000
ALI	29.0	1.73	57235	1.84	99129	1.62	33058	10.0	8.5	8.2	8.5	2.9-7.2	0	0	344000
BFC	0.089	3.35	507980	3.98	4858170	2.72	50890	0.0271	7.0	6.7	7.3	2.9-7.2	0	0	305000
BFS	2.13	1.67	577	1.82	766	1.51	381	0.133	7.0	6.7	7.3	2.9-7.2	0	0	62300
BRP	19.2	1.21	22	1.39	31	1.03	20	0.0486	7.0	6.7	7.3	2.9-7.2	0	0	2530
CAS	1.30	2.01	1402	2.12	1704	1.90	1137	0.0600	7.3	7.1	7.5	2.9-7.2	0	0	46200
CCM	0.074	1.76	81	2.41	400	1.11	18	0.0118	7.0	6.5	7.3	2.9-7.2	0	0	158000
DEN	3.74	1.85	2424	1.94	2982	1.75	2030	0.232	7.0	6.7	7.3	2.9-7.2	0	0	62000
EGA	5.99	2.04	20316	2.12	25399	1.96	16518	0.756	7.9	7.6	8.2	2.9-7.2	0	0	126000
FHL	3.56	2.24	6064	2.66	26533	3.08	111693	0.0834	7.1	7.3	7.5	2.9-7.2	0	0	23400
GEO	0.040	2.27	66	2.79	117	1.76	28	0.0008	7.0	6.5	7.3	50	0	0	19500
GLB	13.7	1.75	896	1.88	1153	1.62	682	0.135	7.0	6.7	7.3	2.9-7.2	0	0	9830
HEC	1.19	2.06	1132	2.17	1323	1.94	1009	0.0383	7.0	6.7	7.3	2.9-7.2	0	0	32000
JDF	0.387	1.97	423	2.10	503	1.84	364	0.0220	7.3	7.2	7.4	2.9-7.2	0	0	56900
MCK	1.76	2.21	35815	2.28	44670	2.13	30775	0.578	7.2	6.9	7.5	2.9-7.2	0	0	328000
NCM	1.07	1.79	333	2.25	1142	1.33	78	0.0420	7.0	6.7	7.3	2.9-7.2	0	0	39100
NEA	0.435	2.20	2555	2.46	4567	1.93	1262	0.0424	7.0	6.7	7.3	2.9-7.2	0	0	97500
NFT	0.009	2.79	2757	3.43	13842	2.15	619	0.0024	7.0	6.7	7.3	2.9-7.2	0	0	275000
NJFP	1.21	1.25	22	1.56	48	0.94	13	0.0394	6.8	6.6	7.0	2.9-7.2	0	0	32400
NJFR	4.77	2.67	47690	3.32	560310	2.01	3856	0.0714	6.0	5.5	6.5	2.9-7.2	0	0	14900
NOF	7.72	1.73	368	1.82	433	1.64	347	0.0624	7.0	6.7	7.3	2.9-7.2	0	0	8090
NRMT	0.074	2.09	278	2.44	558	1.74	156	0.0079	7.0	6.7	7.3	2.9-7.2	0	0	106000
OGL	2.01	1.69	318	1.96	646	1.43	193	0.0651	7.0	6.7	7.3	2.9-7.2	0	0	32300
PUG	3.90	1.01	18	1.12	19	0.90	16	0.105	7.3	7.1	7.6	50	0	0	26800
QCB	0.149	1.96	363	2.39	1101	1.53	140	0.0196	7.0	6.7	7.3	2.9-7.2	0	0	131000
QCF	4.88	1.43	829	1.51	977	1.59	1146	0.641	8.2	8.5	8.7	2.9-7.2	0	0	64600[1]
QCS	5.19	1.43	72	1.67	131	1.19	47	0.0540	7.0	6.7	7.3	2.9-7.2	0	0	10400
RDS	28.1	1.46	2443	1.51	2824	1.41	2226	1.56	7.0	6.8	7.2	2.9-7.2	0	0	55600
RIC	7.14	2.06	3519	2.21	4797	1.92	2392	0.115	7.0	6.7	7.3	2.9-7.2	0	0	16000
SCM	0.441	1.70	129	1.85	153	1.55	108	0.0254	7.0	6.5	7.3	2.9-7.2	0	0	57700
SEBC	0.323	1.81	854	1.95	1168	1.68	634	0.0965	7.0	6.7	7.3	2.9-7.2	0	0	298000
SFT	0.146	2.48	4878	2.74	9370	2.22	2514	0.0186	6.0	5.0	7.0	2.9-7.2	0	0	127000
SYT	0.185	1.93	529	2.25	1050	1.61	239	0.0337	7.0	6.7	7.3	2.9-7.2	0	0	181000
YFF	8.88	2.13	27728	2.21	35213	2.05	22338	0.661	8.5	8.2	8.7	2.9-7.2	0	0	74400

Notes

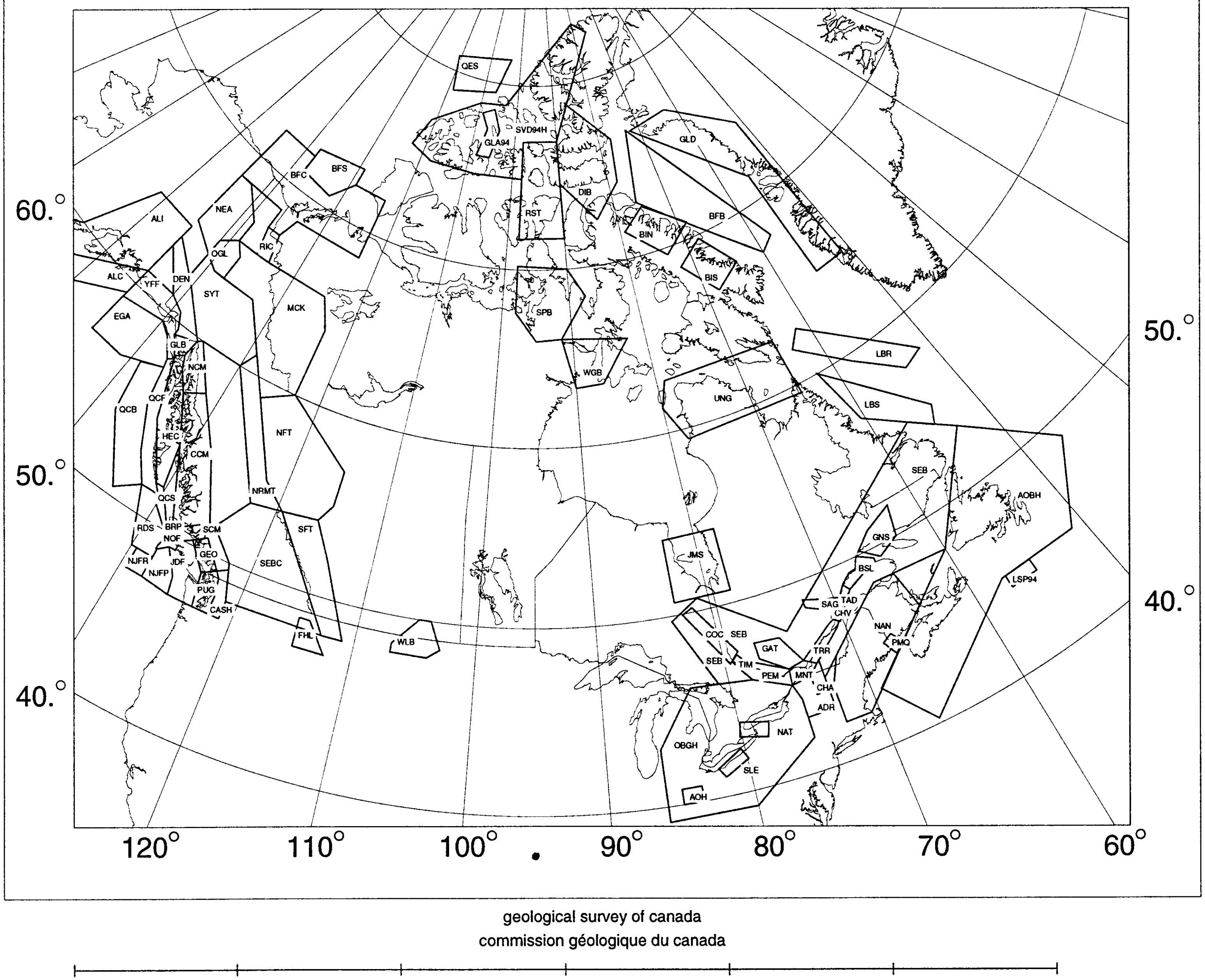
[1]moment magnitude - see note on MX below.

MX - The represents the upper-bound magnitude and is taken to be m_{bLg} for the eastern (with exceptions below) and moment magnitude for the western zones. For eastern and arctic offshore zones, the upper-bound magnitude is defined in terms of moment magnitude and given on the second line; equivalent m_{bLg} magnitudes are given on the first line. These are the values input into the FRISK88 code, where they are reconverted to moment magnitudes (using the inverse relation) for calculation of the hazard.

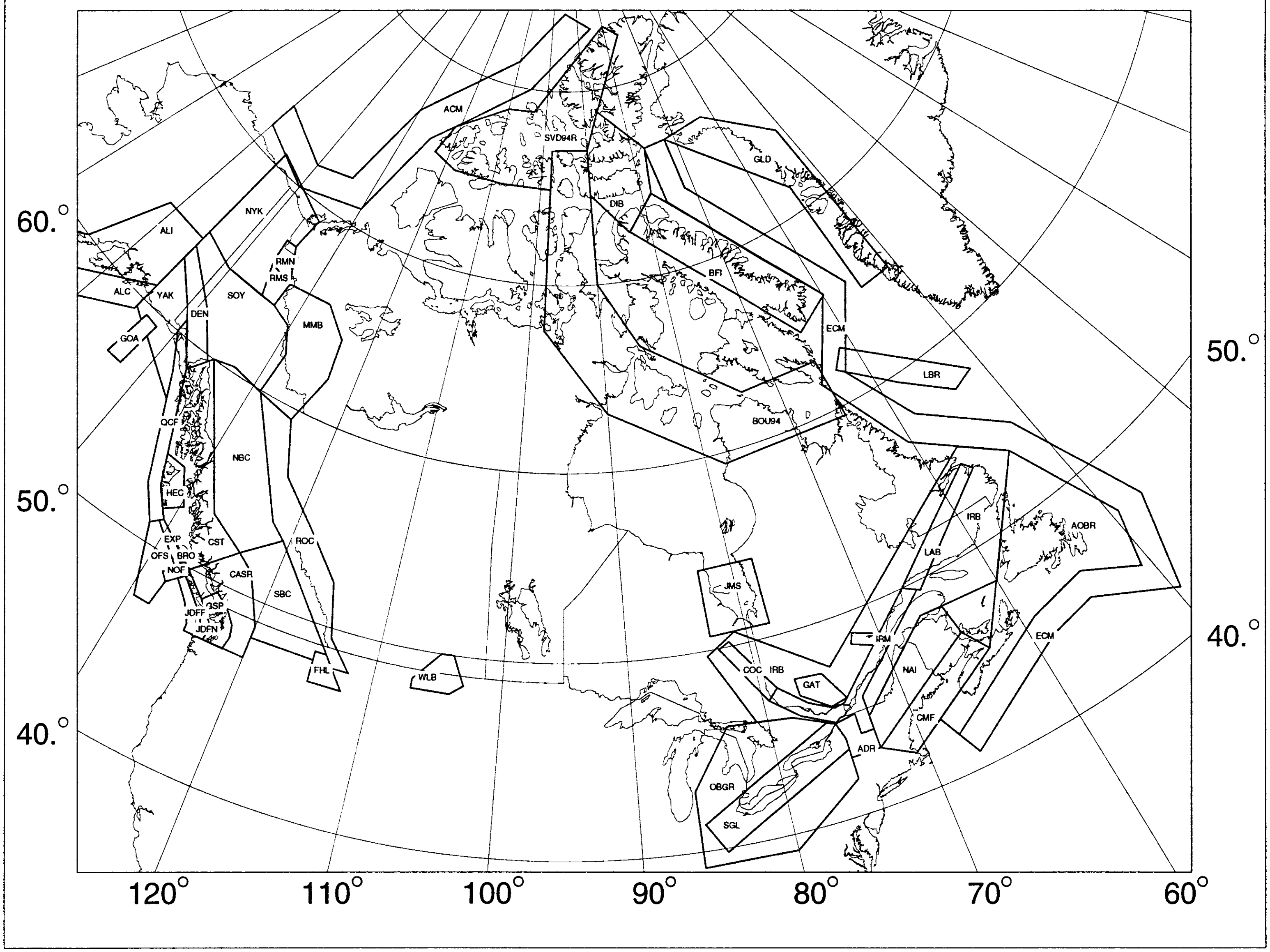
F - Zones with BETA flagged with F have has a slope imposed rather than derived from a maximum likelihood fit to the data.

[1] - Note that QCF is a fault zone and the area is NOT the area of the fault. This figure represents the area near the fault used to choose the earthquakes that are included in the magnitude recurrence calculation.

CANADA 1994 - MODEL H SEISMIC ZONES



CANADA 1994 - MODEL R SEISMIC ZONES



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commission géologique du canada

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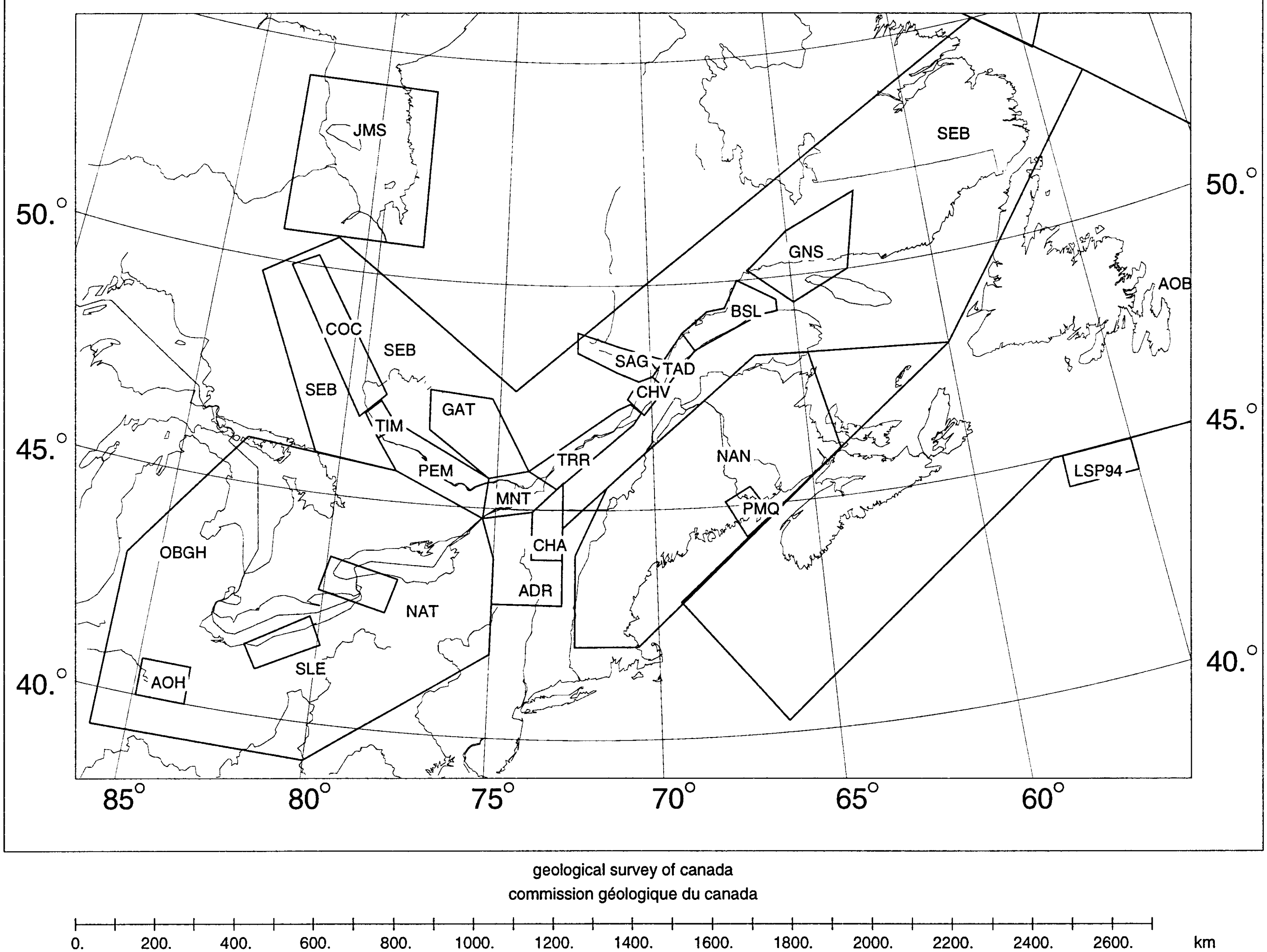
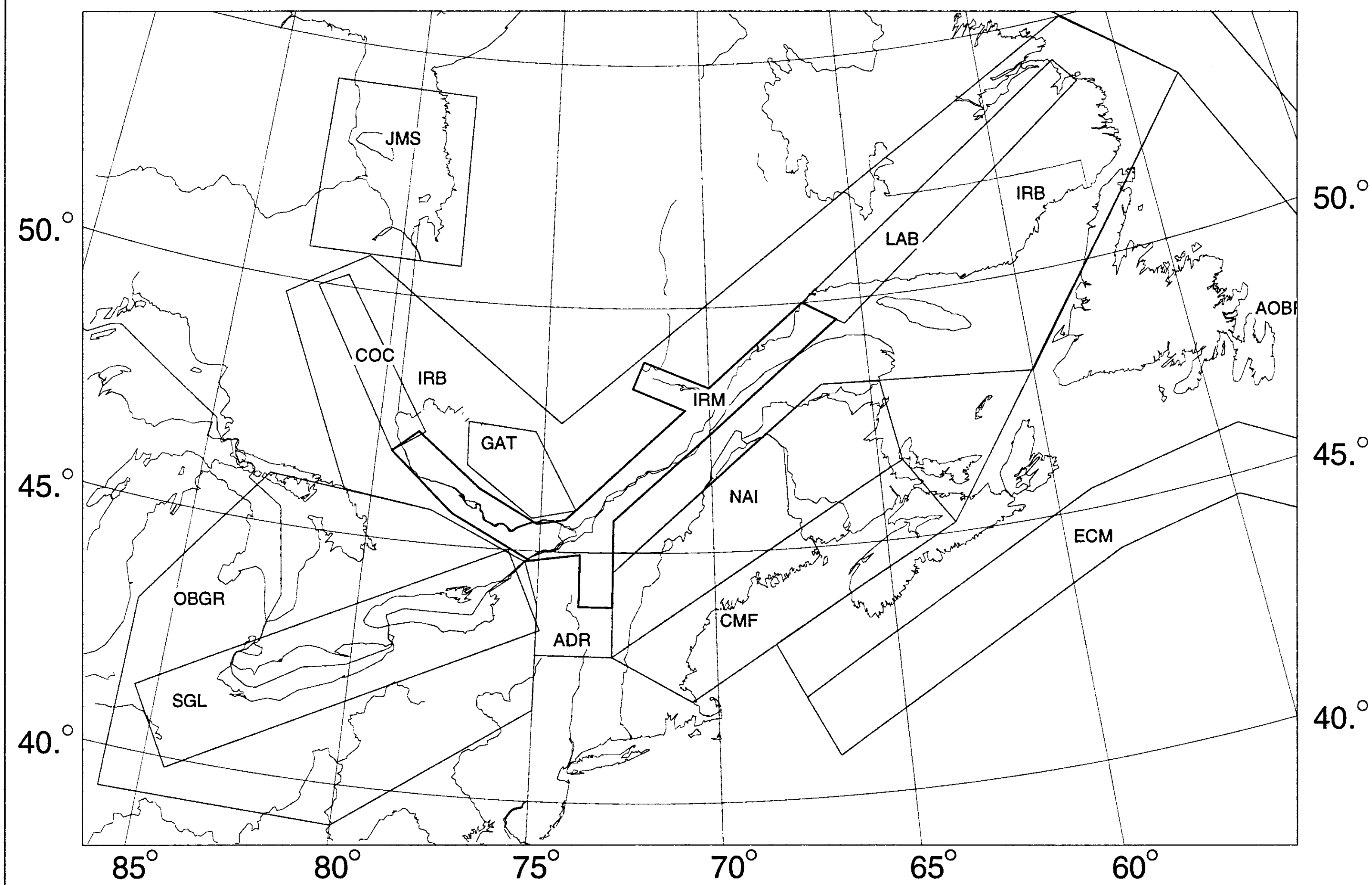
SOUTHEASTERN CANADIAN - 1994 MODEL H ZONES



geological survey of canada
commission géologique du canada

78c

SOUTHEASTERN CANADIAN - 1994 MODEL R ZONES



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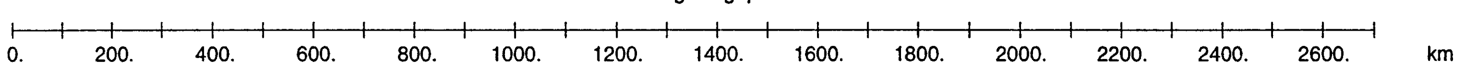
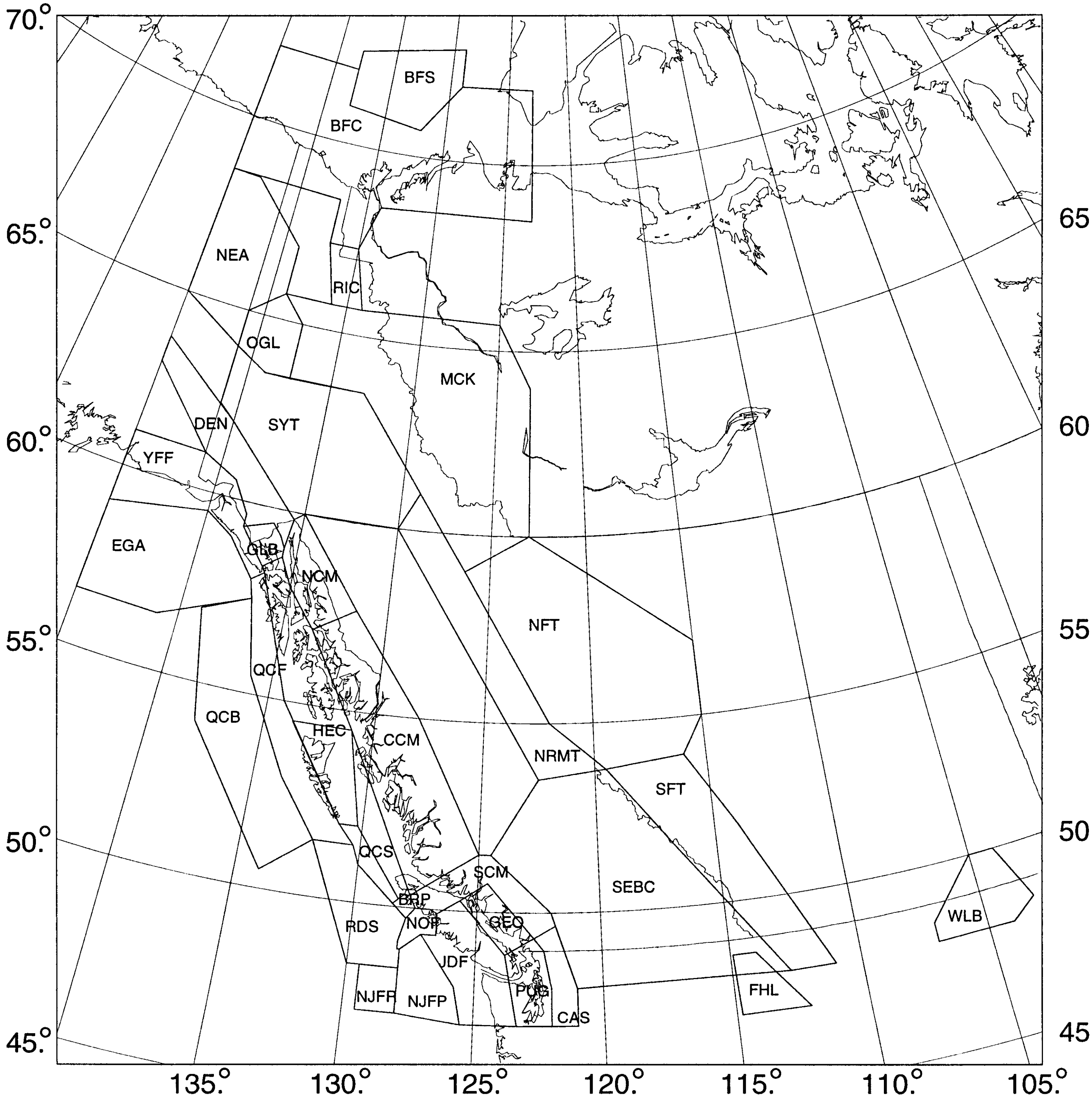
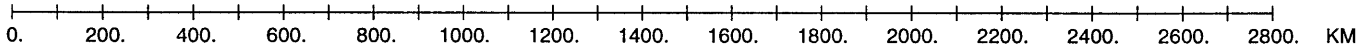
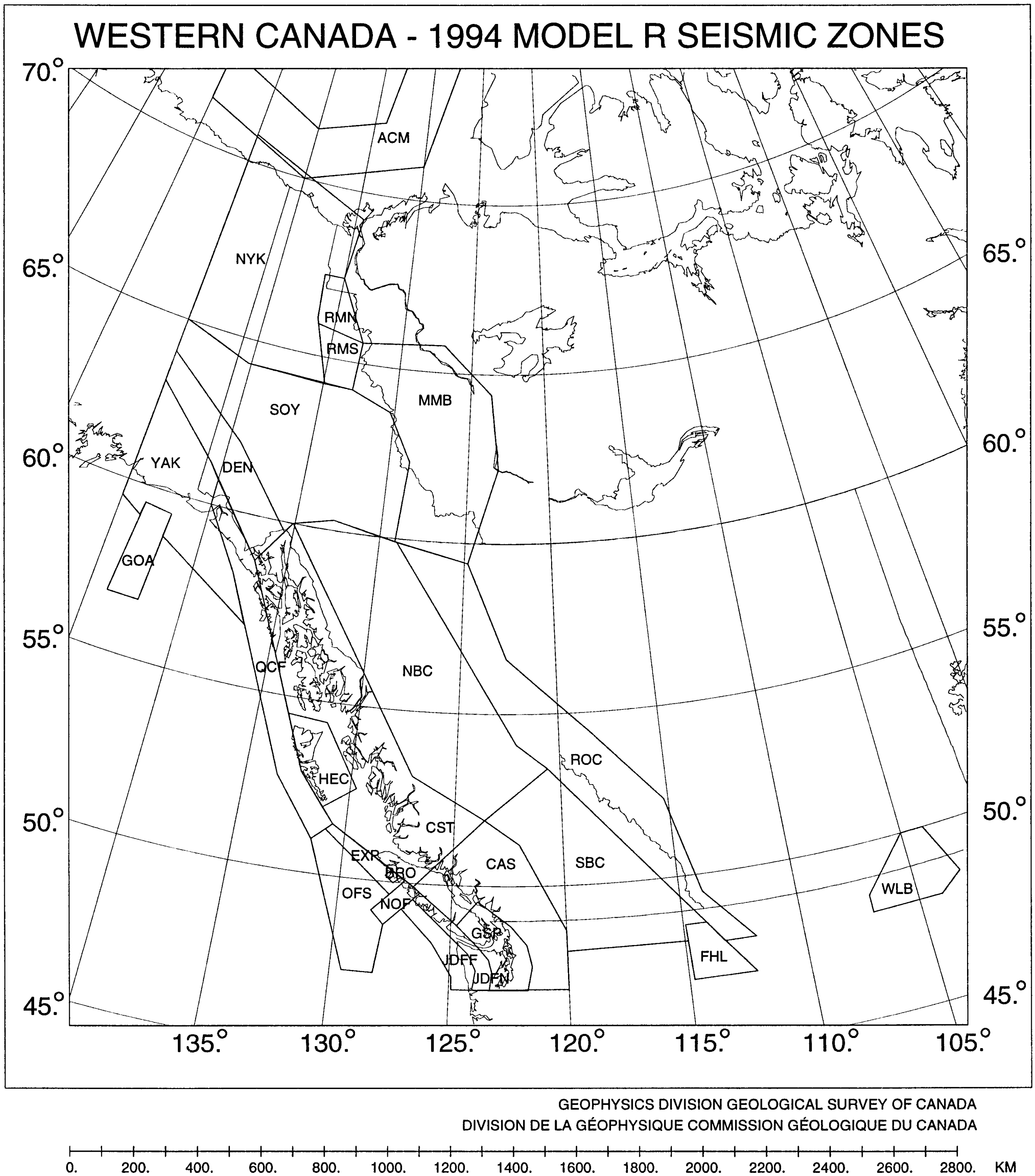


WESTERN CANADA - 1994 MODEL H SEISMIC ZONES



GEOPHYSICS DIVISION GEOLOGICAL SURVEY OF CANADA
DIVISION DE LA GÉOPHYSIQUE COMMISSION GÉOLOGIQUE DU CANADA




WESTERN CANADA - 1994 MODEL R SEISMIC ZONES
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DIVISION DE LA GÉOPHYSIQUE COMMISSION GÉOLOGIQUE DU CANADA
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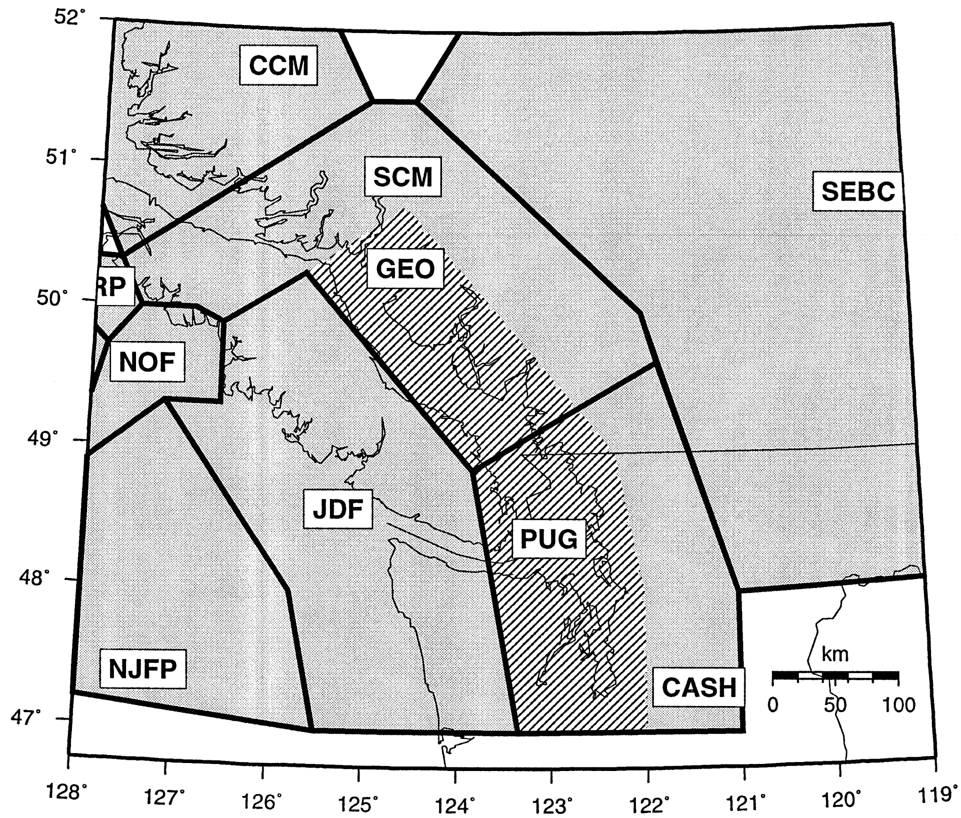
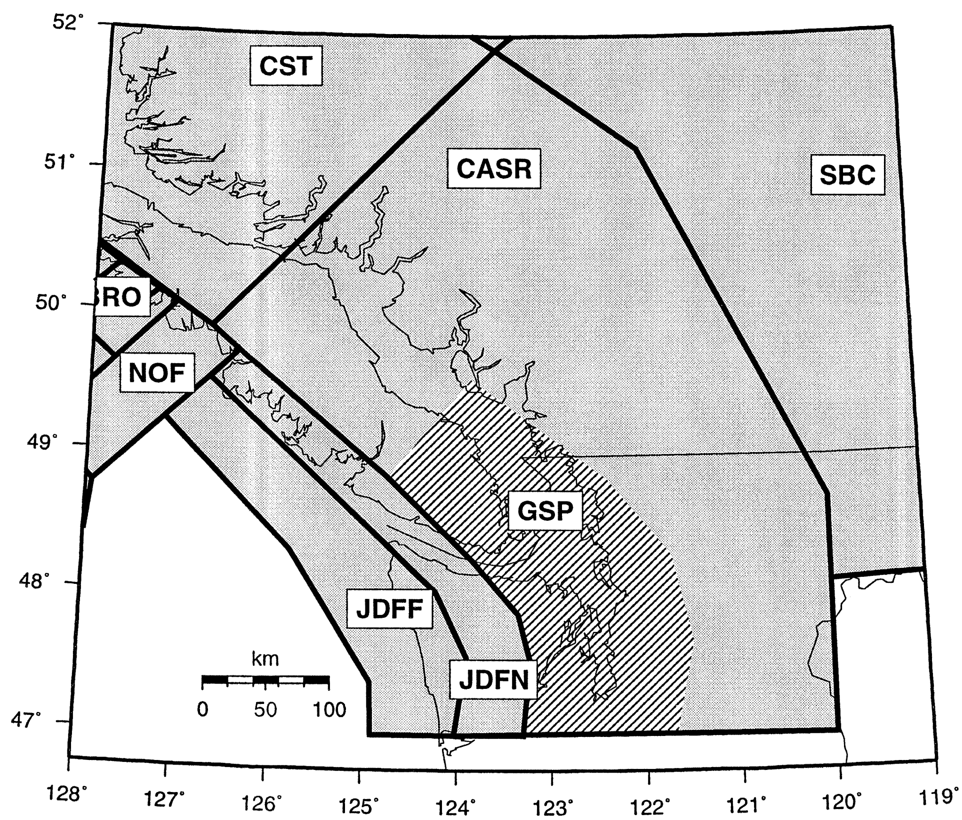


Southwestern British Columbia H model zones

Zone GEO lies below zone SCM
Zone PUG lies below zone CASH



Southwestern British Columbia R model zones

Zone GSP lies below zone CASR

APPENDIX D

Input models for FRISK88 seismic hazard code (including strong ground motion parameters)

The pages which follow this page contain (in 2-column format) the input files for the four models used to generate the 1 s spectral acceleration values in Table 4, followed by a listing of the strong ground motion parameters used for each period. This page annotates the beginning of the first file.

```
1995 Eastern Canada model H Atkinson 95 attenuation PSA 1.0 s
Data for INTERP subroutine
4  0.01       0.0021      0.001      0.000404                       ! Probability levels
Main data set for FRISKGSC program
3  50  5.0  5.0  0.10  4  1                                         ! Array sizes, integration
increments
24  1. 3. 10. 13.5 17.5 23.5 30. 42. 60. 75. 100. 135. 175. 235. 300. 420. ! Ground motion interpolation points
600. 750. 1000. 1350. 1750. 2350. 3000. 4200.
0.44 0.14 0.42                                                      ! weights for attenuation relations
A
AB95R PSA 1s  Median grd motion for PSA1.0s ATKINSON BOORE 1995     ! Best attenuation relation
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0        !       Attenuation parameters
AB95R PSA 1s  L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit  ! Lower attenuation relation
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0        !       Attenuation parameters
AB95R PSA 1s  U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit  ! Upper attenuation relation
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0        !       Attenuation parameters
1  1.0
H - MODEL 1995  37 ZONES  HISTORICAL ZONES
37  3  3  3  37  20                                                 !
0.6 0.3 0.1                                                         ! weights for Maximum magnitudes
0.68 0.16 0.16                                                      ! weights for magnitude recurrence
0.5 0.25 0.25                                                       ! weights for depths
1  1  1  1
ADR    - NORTHERN ADIRONDACKS                                       ! Zone name
1
ONLY ALTERNATIVE
1.
area                                                                ! type of zone (area/fault)
10.0  20.0  5.0                                                     ! depth to hypocentres/JB
pseudo-depth
7                                                                   ! number of zone corner coordinates
-75.39  44.77                                                       ! longitude/latitude pairs
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5                                                    ! minimum and maximum magnitudes
1
142. 1.84  291. 2.19  60. 1.50                                      ! No/β pairs (best, lower, upper)
```

PSA 1.0 sec 1995 Eastern Canada model H Atkinson 95 attenuation

```
Data for INTERP subroutine
4  0.01  0.0021  0.001 0.000404
Main data set for FRISKGSC program
3  50  5.0  5.0  0.10  4  1
24  1. 3. 10. 13.5 17.5 23.5 30. 42. 60. 75. 100. 135. 175. 235.
300.
420. 600. 750. 1000. 1350. 1750. 2350. 3000. 4200.
0.44 0.14 0.42
A
AB95R PSA 1s Mlg Median grd motion for PSA1.0s ATKINSON BOORE 1995
Mlg
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg L grd motion for PSA1.0s ATKINSON BOORE 1995 L
limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s Mlg U grd motion for PSA1.0s ATKINSON BOORE 1995 U
limit
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
1  1.0
H - MODEL 1995  37 ZONES  HISTORICAL ZONES
37  3  3  3  37  20
0.6 0.3 0.1
0.68 0.16 0.16
0.5 0.25 0.25
1  1  1  1
ADR    - NORTHERN ADIRONDACKS
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
7
-75.39  44.77
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5
1
142. 1.84  291. 2.19  60. 1.50
AOBH   - ATLANTIC OFFSHORE BACKGROUND (H model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
7
-53.10  53.20
-46.70  49.00
-51.00  44.90
-57.50  45.00
-66.40  40.25
-69.30  42.95
-60.00  48.00
4.75  7.5 6.0 7.5
1
755. 2.00  1530. 2.20  927. 1.80
AOH    - ANNA OHIO
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
4
-84.90  40.00
-83.50  40.00
-83.50  40.80
-84.90  40.80
4.75  7.0 6.0 7.5
1
575. 2.05  402. 2.15  700. 1.95
BFB    - BAFFIN BAY
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-60.00  67.40
-57.70  68.00
-64.30  73.00
-73.10  76.80
-75.80  72.90
-71.00  71.60
4.75 7.5 7.3 8.0
1
884. 1.64  1570. 1.84  485. 1.45
BIN     - BAFFIN ISLAND NORTH
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
4
-73.40  69.60
-68.50  70.90
-75.10  72.60
-79.20  71.50
4.75  7.0 6.5 7.5
1
1730. 1.92  2440. 2.09  1000. 1.75
BIS     - BAFFIN ISLAND SOUTH
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
4
-67.80  69.80
-64.10  67.70
-68.10  66.70
-72.10  68.70
4.75 7.0 6.0 7.5
1
558. 1.92  705. 2.09  351. 1.75
BSL    - BAS SAINT LAURENT
1
ONLY ALTERNATIVE
1.
```

```
area
10.0 20.0 5.0
8
-68.90  48.90
-68.00  49.35
-67.40  49.40
-66.90  50.00
-65.60  49.50
-65.60  49.25
-66.20  49.20
-68.50  48.50
4.75  7.5 6.0 7.7
1
533. 1.93  781. 2.13  344. 1.74
CHA    - CHAMPLAIN
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-73.85  44.95
-72.90  45.60
-72.90  43.90
-73.85  43.90
4.75  7.5 6.0 7.7
1
107. 2.00  92. 2.10  120. 1.90
CHV    - CHARLEVOIX
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-70.25  47.10
-69.53  47.69
-69.95  47.95
-70.40  47.85
-70.79  47.46
4.75  7.5 7.2 7.7
1
374. 1.74  477. 1.85  310 1.62
COC    - COCHRANE
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-81.60  50.25
-82.50  49.95
-79.55  46.80
-78.75  47.35
4.75 7.5 6.0 7.7
1
76. 2.00  74. 2.10  126. 1.90
DIB    -  DEVON ISLAND BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-83.60  72.50
-78.20  74.30
-77.10  76.60
-86.50  78.90
-90.00  77.00
-90.00  74.70
4.75  7.0 6.0 7.5
1
1200. 2.25  2330. 2.55  600. 1.95
GAT    - GATINEAU
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
5
-75.26  47.43
-74.00  45.85
-75.26  45.66
-77.26  46.66
-77.32  47.55
4.75 7.0 6.5 7.5
1
1190. 2.07  1580. 2.23  811. 1.91
GLA94  - GUSTAF LOUGHEED ARCH
1
ONLY ALTERNATIVE
1.
area
10.0 30.0 5.0
6
-108.50  76.00
-105.50  76.00
-104.00  77.50
-106.00  78.60
-109.00  78.30
-107.00  77.50
4.75 7.0 6.5 7.5
1
206. 1.54  597. 1.90  65. 1.18
GLD     - GREENLAND         Original magnitudes  7.5 7.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-55.30  64.85
-51.10  64.85
-51.10  74.15
-62.60  76.95
-72.20  76.70
-55.30  71.35
4.75  7.33 7.0 7.63
1
500. 1.70  78300. 3.11  285. 1.50
GNS    - GULF OF ST. LAWRENCE - NORTH SHORE
1
ONLY ALTERNATIVE
1.
```

```
area
10.0 20.0 5.0
5
-65.00  49.40
-63.00  50.00
-62.40  51.70
-65.00  51.00
-66.50  50.20
4.75  7.5 6.0 7.7
1
237. 2.00  248. 2.10  223. 1.90
JMS    - JAMES BAY
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-83.00  50.70
-78.00  50.70
-78.00  54.20
-83.00  54.20
4.75 6.5 6.0 6.7
1
167. 2.00  190. 2.10  237. 1.90
LBR    - LABRADOR RIDGE              Original magnitudes 6.5 6.0
7.5
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-61.50  62.80
-63.10  61.85
-58.00  59.60
-53.60  57.50
-51.20  57.90
-55.00  60.00
4.75  6.66 6.29 7.33
1
3970. 2.00  21900. 2.46  3210. 1.90
LBS    - LABRADOR SHELF             Original magnitudes 7.5 6.5
8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-54.70  54.00
-53.80  55.00
-62.00  60.00
-60.40  56.60
4.75  7.33 6.66 7.63
1
358. 1.70  11100. 2.61  225. 1.50
LSP94  - LAURENTIAN SLOPE          Original magnitudes 7.5 7.5 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-57.20  44.30
-55.00  44.30
-55.00  45.00
-57.20  45.00
4.75 7.33 7.33 7.63
1
278. 1.70  404. 1.90  140. 1.44
MNT    - MONTREAL
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-74.00  45.85
-73.10  45.46
-73.85  44.95
-75.39  44.77
-75.26  45.66
4.75  7.5 6.5 7.7
1
258. 1.96  405. 2.19  167. 1.74
NAN   - NORTHERN APPALACHIANS
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
7
-70.60  42.00
-64.00  46.05
-64.70  48.25
-66.50  48.30
-71.50  45.50
-72.50  44.00
-72.50  42.00
4.75  7.0 6.0 7.0
1
374. 1.75  508. 1.90  276. 1.60
NAT   - NIAGARA ATTICA TREND  (1994)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  5.0
4
-77.85  43.30
-79.90  43.65
-80.15  42.90
-78.15  42.55
4.75  7.0 6.0 7.5
1
69. 1.80  164. 2.23  29. 1.37
OBGH   - ONTARIO BACKGROUND (H model)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  10.0
8
```

```
-86.00  39.20
-80.00  39.20
-75.00  41.80
-75.00  43.90
-75.39  44.77
-78.21  45.68
-83.00  46.00
-86.00  43.00
4.75  6.5 6.0 6.7
1
273. 2.00  346. 2.20  176 1.80
PEM    - PEMBROKE
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-78.20  46.70
-75.26  45.66
-75.39  44.77
-78.21  45.68
-78.89  46.36
4.75  7.5 6.0 7.7
1
140. 1.95  271 2.34  55. 1.57
PMQ    - PASSAMAQUODDY BAY
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-67.00  45.40
-66.40  44.75
-67.20  44.30
-67.80  45.10
4.75 7.0 6.5 7.5
1
49. 1.72  124. 2.17  18. 1.26
QES    - QUEEN ELIZABETH SHELF  original magnitudes  7.5 6.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-118.70  79.00
-106.60  79.50
-103.20  81.30
-120.70  80.80
4.75 7.33 6.29  7.63
1
1175. 2.00  2310. 2.25  570. 1.75
RST    - RESOLUTE
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-90.00 77.00
-98.00 77.00
-98.00 71.70
-90.00 71.70
4.75  7.0 6.5 7.5
1
914. 2.00 1920. 2.28  406. 1.72
SAG    - SAGUENAY
1
ONLY ALTERNATIVE
1.
area
10.0 30.0 5.0
7
-71.00  48.62
-69.54  48.32
-69.95  47.95
-70.40  47.85
-71.10  48.05
-72.45  48.50
-72.45  48.95
4.75 7.5 6.5 7.7
1
89. 2.00  67. 2.10   84. 1.90
SEB    - SOUTHEAST CANADA BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
14
-72.90  44.60
-66.50  48.30
-60.00  48.00
-53.10  53.20
-56.70  55.00
-74.50  47.62
-81.00  50.70
-83.50  49.70
-80.80  45.90
-78.21  45.68
-75.39  44.77
-75.00  43.90
-75.00  42.90
-72.90  42.90
4.75  7.0 6.0 7.5
1
649.  2.00  25400 3.33  532  1.80
SLE    - SOUTH SHORE LAKE ERIE
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
4
-81.70  41.00
-79.90  41.70
-80.30  42.30
-82.10  41.50
4.75  7.0 6.0 7.5
1
169. 2.09  457. 2.57  61. 1.61
SPB    - SPENCE BAY
```

```
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-91.50 66.10
-87.50 68.40
-90.00 70.00
-98.00 70.20
-98.00 67.60
-95.00 66.00
4.75  7.0 6.5 7.5
1
374. 2.00 478. 2.20  88. 1.34
SVD94H - SVERDRUP BASIN  - No GLA events (H model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
11
-117.80  75.00
-108.00  75.00
 -98.00  75.00
 -98.00  77.00
 -90.00  77.00
 -75.00  82.40
 -80.00  83.00
-103.20  78.90
-110.00  78.80
-121.00  77.10
-122.90  75.50
4.75  7.0 6.5 7.5
1
6330. 2.25  16300. 2.55  2390. 1.95
TIM    - TIMISKAMING
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-78.30  46.65
-78.89  46.36
-79.37  46.89
-78.90  47.20
4.75  7.5 6.5 7.7
1
63. 2.00  47. 2.10  65. 1.90
TRR    - TROIS-RIVIERES
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-71.14  47.22
-70.70  47.35
-70.35  47.15
-70.60  46.90
-73.10  45.46
-74.00  45.85
4.75 7.5 6.0 7.7
1
113. 2.00  113. 2.10  122. 1.90
UNG    - UNGAVA
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
5
-78.00  59.40
-64.50  59.50
-64.80  62.80
-79.00  62.90
-80.00  61.40
4.75  7.0 6.5 7.5
1
849. 2.00 1700. 2.28  60. 1.24
WGB    - WEGER BAY
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
4
-90.00  63.30
-86.50  63.40
-82.50  65.70
-91.50  66.10
4.75  7.0 6.5 7.5
1
737. 2.00 1470. 2.28  336. 1.72
WLB    - WILLISTON BASIN
1
WLB
1.0
area
10.0  20.0  5.0

6
-104.00  50.00
-103.00  48.50
-104.00  48.00
-107.00  48.00
-107.00  48.50
-105.00  50.00
4.75 6.0 5.5 6.5
1
28.28 1.6590   16.74 2.2590   39.83 1.0590
```

PSA 1.0 sec 1995 seismic hazard for E Canada model R

```
Data for INTERP subroutine
4  0.01  0.0021  0.001 0.000404
Main data set for FRISKGSC program
3  50  5.0  5.0  0.10  4  1
24  1. 3. 10. 13.5 17.5 23.5 30. 42. 60. 75. 100. 135. 175. 235.
300. 420. 600. 750. 1000. 1350. 1750. 2350. 3000. 4200.
0.44 0.14 0.42
A
AB94R PSA 1s Mlg Median grd motion for Pseudo Acc 1 sec ATKINSON
BOORE 1994 Mlg
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB94R PSA 1s Mlg L grd motion for PSA 1 sec ATKINSON BOORE 1994 Mlg
Lower limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB94R PSA 1s Mlg U grd motion for PSA 1 sec ATKINSON BOORE 1994 Mlg
Upper limit
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
1  1.0
R - MODEL 1995  21 ZONES REGIONAL ZONES
21  3  3  3  21  22
0.6 0.3 0.1
0.68 0.16 0.16
0.5 0.25 0.25
1  1  1  1
ACM     - ARCTIC CONTINENTAL MARGIN   Original magnitudes 7.5 7.0
8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
13
-150.00  71.30
-140.00  70.00
-130.00  71.00
-125.00  76.00
-121.00  77.10
-105.00  80.00
 -85.00  83.00
 -95.00  83.80
-110.00  81.25
-130.00  77.00
-134.00  72.10
-140.00  71.50
-150.00  72.80
4.75  7.33 7.0 7.63
1
5100. 2.08  11600. 2.34  2250. 1.83
ADR    - NORTHERN ADIRONDACKS
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
7
-75.39  44.77
-73.85  44.95
-73.85  43.90
-72.90  43.90
-72.90  42.90
-75.00  42.90
-75.00  43.90
4.75 7.0 6.0 7.5
1
142. 1.84  291. 2.19  60. 1.50
AOBR   - ATLANTIC OFFSHORE BACKGROUND (R model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
8
-53.10  53.20
-49.40  47.20
-50.70  44.30
-54.40  46.00
-59.00  45.40
-67.60  42.00
-68.35  43.10
-63.00  45.20
4.75  7.0 6.0 7.5
1
587. 2.00  873. 2.20  514. 1.80
BFI    - BAFFIN ISLAND
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
8
-59.85  65.65
-65.00  69.00
-71.25  72.00
-78.20  74.25
-83.60  72.55
-75.20  69.90
-70.05  67.70
-64.70  64.50
4.75  7.0 6.5 7.5
1
2390. 1.92  3490. 2.09  1380. 1.74
BOU94  - BOOTHIA UNGAVA
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
10
-64.50  59.50
-64.80  62.80
-74.00  62.80
-85.00  66.50
-90.00  70.00
-90.00  77.00
-98.00  77.00
-98.00  67.60
-90.00  63.10
-78.00  59.40
4.75 7.0 6.5 7.5
1
3150. 2.02  7730. 2.30  1250. 1.74
```

```
CMF    - COASTAL MAINE FUNDY
1
ONLY ALTERNATIVE

1.
area
10.0  20.0  5.0
5
-72.90  42.90
-70.70  42.00
-63.00  45.20
-64.30  46.60
-68.40  45.00
4.75  7.0 6.5 7.5
1
425. 2.02  696. 2.27  247. 1.78
COC    - COCHRANE
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-81.60  50.25
-82.50  49.95
-79.55  46.80
-78.75  47.35
4.75 7.5 6.0 7.7
1
76. 2.00  74. 2.10  126. 1.90
DIB    -  DEVON ISLAND BACKGROUND
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-83.60  72.50
-78.20  74.30
-77.10  76.60
-86.50  78.90
-90.00  77.00
-90.00  74.70
4.75  7.0 6.0 7.5
1
1200. 2.25  2330. 2.55  600. 1.95
ECM    - EASTERN CONTINENTAL MARGIN     Original magnitudes 7.5 7.3
8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
22
-66.80  40.80
-58.50  44.10
-54.90  44.60
-49.60  42.20
-47.20  47.10
-51.40  54.30
-58.30  57.70
-62.30  61.50
-56.60  65.60
-71.70  74.00
-72.20  76.70
-77.15  76.60
-75.70  73.60
-59.90  65.70
-65.30  61.50
-60.30  56.60
-53.10  53.20
-49.40  47.20
-50.70  44.30
-54.40  46.00
-59.00  45.40
-67.60  42.00
4.75 7.33 7.20 7.63
1
1840. 1.70  3460. 1.90  956. 1.50
GAT    - GATINEAU
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
5
-75.26  47.43
-74.00  45.85
-75.26  45.66
-77.26  46.66
-77.32  47.55
4.75 7.0 6.5 7.5
1
1190. 2.07  1580. 2.23  811. 1.91
GLD    - GREENLAND         Original magnitudes  7.5 7.0 8.0
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-55.30  64.85
-51.10  64.85
-51.10  74.15
-62.60  76.95
-72.20  76.70
-55.30  71.35
4.75  7.33 7.0 7.63
1
500. 1.70  78300. 3.11  285. 1.50
IRB    - Iapetan Rift Background
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
14
-72.90  44.60
```

```
-66.50  48.30
-60.00  48.00
-53.10  53.20
-56.70  55.00
-74.50  47.62
-81.00  50.70
-83.50  49.70
-80.80  45.90
-78.21  45.68
-75.39  44.77
-75.00  43.90
-75.00  42.90
-72.90  42.90
4.75  7.0 6.0 7.5
1
630. 2.00  844. 2.10  688. 1.90
IRM    - Iapetan Rift Margin
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
18
-72.90  43.90
-72.90  45.65
-70.00  47.40
-65.85  49.60
-66.90  50.00
-70.00  48.35
-72.00  48.90
-72.35  48.35
-70.75  47.90
-74.30  45.65
-75.10  45.55
-76.85  46.20
-78.75  47.35
-79.55  46.80
-77.60  45.65
-75.25  44.80
-73.85  44.95
-73.85  43.90
4.75  7.5 7.2 7.7
1
2220. 1.98  2720. 2.07  1810. 1.88
JMS    - JAMES BAY
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-83.00  50.70
-78.00  50.70
-78.00  54.20
-83.00  54.20
4.75 6.5 6.0 6.7
1
167. 2.00  190. 2.10  237. 1.90
LAB    - SOUTHERN LABRADOR
1
ONLY ALTERNATIVE
1.
area
10.0  20.0  5.0
4
-66.90  50.00
-65.60  49.50
-56.60  53.61
-57.29  54.15
4.75 7.5 6.0 7.7
1
155. 2.00  131. 2.10  164. 1.90
LBR    - LABRADOR RIDGE                Original magnitudes 6.5 6.0
7.5
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
6
-61.50  62.80
-63.10  61.85
-58.00  59.60
-53.60  57.50
-51.20  57.90
-55.00  60.00
4.75  6.66 6.29 7.33
1
3970. 2.00  21900. 2.46  3210. 1.90
NAI    - NORTHERN APPALACHIANS INTERIOR
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 5.0
7
-72.90  42.90
-68.40  45.00
-64.30  46.60
-64.70  48.25
-66.50  48.30
-69.00  47.00
-72.90  44.60
4.75  7.0 6.0 7.0
1
111. 1.51  152. 1.68  79. 1.33
OBGR   - ONTARIO BACKGROUND (R MODEL)
1
ONLY ALTERNATIVE
1.
area
5.0  20.0  10.0
8
-86.00  39.20
-80.00  39.20
-75.00  41.80
-75.00  43.90
-75.39  44.77
-78.21  45.68
-83.00  46.00
-86.00  43.00
4.75  6.5 6.0 6.7
1
144. 2.00  156. 2.20  100. 1.80
```

```
SGL    - SOUTHERN GREAT LAKES
1
ONLY ALTERNATIVE
1.
area
5.0 20.0 10.0
6
-84.40  39.80
-75.00  43.35
-75.00  43.90
-75.39  44.77
-76.00  44.95
-85.60  41.30
4.75  7.0 6.0 7.5
1
454. 1.99  724. 2.23  262. 1.75
SVD94R - SVERDRUP BASIN ALL EVENTS (R model)
1
ONLY ALTERNATIVE
1.
area
10.0 20.0 5.0
11
-117.80  75.00
-108.00  75.00
 -98.00  75.00
 -98.00  77.00
 -90.00  77.00
 -75.00  82.40
 -80.00  83.00
-103.20  78.90
-110.00  78.80
-121.00  77.10
-122.90  75.50
4.75  7.0 6.5 7.5
1
9170. 2.25  23000. 2.53  3590. 1.96
WLB    - WILLISTON BASIN
1
WLB
1.0
area
10.0  20.0  5.0

6
-104.000  50.000
-103.000  48.500
-104.000  48.000
-107.000  48.000
-107.000  48.500
-105.000  50.000
4.75 6.0 5.5 6.5
1
28.28 1.6590   16.74 2.2590   39.83 1.0590
```

PSA 1.0 sec WEST H model deep-Youngs etal97

```
Probilities of Exceedence for INTERP Subroutine in GSCFRISK.
4  0.01  0.0021  0.001 0.000404
Data Set for Integrations in GSCFRISK.
6 50 5.0 5.0 0.10 4 2
24  1. 3. 10. 13.5 17.5 23.5 30. 42. 60. 75. 100. 135. 175. 235. 300.
420. 600. 750. 1000. 1350. 1750. 2350. 3000. 4200.
3 1 0.3 2 0.4 3 0.3
B
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3
declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3
declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) + 0.7 nat
log
-1.036  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s)
-1.736  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) - 0.7 nat
log
-2.436  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
1 1.0
HORNER'S 1992 SOURCE ZONES (RBH92)
34  3  3  1  34  12
0.68  0.16  0.16
0.68  0.16  0.16
1.0
1  1  1  1
ALASKA COASTAL
1
ALC
1.0
area
****************************************
Borrowed from USGS; No Completeness Data.
****************************************
2.90  !JB-pseudo_depth
4
-145.000  61.000
-145.000  59.300
-156.000  54.700
-157.500  55.800
4.75  8.5 8.2 8.7
1
3848.1 1.43  5731.25 1.51 2585.08 1.35
ALASKA INLAND
1
ALI
1.0
area
****************************************
Borrowed from USGS; No Completeness Data.
****************************************
2.90  !JB-pseudo_depth
7
-145.000  64.500
-145.000  61.000
-157.500  55.800
-160.000  54.300
-160.000  57.000
-154.000  60.000
-151.000  64.500
4.75  8.5 8.2 8.5
1
57235.7 1.73  99129.5 1.84 33058.6 1.62
BEAUFORT COAST
1
BFC
1.0
area
6
4.0   4.8   5.3   5.8   6.3   7.2
1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   12
-123.00 72.00
-123.00 68.50
-134.00 68.50
-135.00 67.30
-137.00 67.30
-137.00 68.50
-145.00 68.50
-145.00 72.00
-138.00 72.00
-138.00 71.00
-132.00 70.70
-129.00 72.00
4.75  7.0 6.7 7.3
1
507980.34  3.3488  4858170.0  3.9772  50890.54  2.7205   !created
20/09/95
BEAUFORT SEA
1
BFS
1.0
area
8
3.0   3.3   3.8   4.8   5.3   5.8   6.3   7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   5
-129.00 73.00
-129.00 72.00
-132.00 70.70
-138.00 71.00
-138.00 72.50
4.75  7.0 6.7 7.3
1
577.51  1.6683  766.80  1.8244  381.16  1.5123   !created 20/09/95
BROOKS PENINSULA
1
BRP
1.0
area
```

```
7
2.0   2.8   3.3   3.8   4.8   5.3   6.8
1982  1962  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-128.00 50.33
-127.75 50.33
-127.50 50.00
-127.85 49.72
-128.43 50.08
4.75  7.0 6.7 7.3
1
22.86  1.2120  31.11  1.3908  20.40  1.0332   !created 20/09/95
CASCADE MOUNTAINS ! Modified
1
CAS         (shallow)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   5
-121.83 49.65
-121.00 48.00
-121.00 47.00
-123.35 47.00
-123.84 48.88
4.75  7.3 7.1 7.5
1
1402.9 2.01  1704.1 2.12 1137.9 1.90 ! Modified 15/12/95 984.93
1.8647  1164.53  1.9627  826.08  1.7668   !created 20/09/95
CENTRAL COAST MOUNTAINS
1
CCM
1.0
area
6
3.0   3.3   3.8   5.3   5.8   6.8
1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   6
-131.55 57.67
-128.00 55.00
-125.00 51.50
-127.75 50.33
-131.00 54.50
-133.55 57.00
4.75  7.0 6.5 7.3
1
81.39  1.7624  400.87  2.4103  18.83  1.1146   !created 20/09/95
DENALI FAULT
1
DEN
1.0
area
8
2.8   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   11
-145.00 63.70
-140.00 62.00
-135.50 59.80
-135.70 59.00
-136.00 59.30
-136.50 59.60
-138.00 59.33
-138.00 59.67
-139.00 60.50
-141.00 61.00
-145.00 63.00
4.75  7.0 6.7 7.3
1
2424.71  1.8459  2982.22  1.9401 2030.76  1.7517   !created
20/09/95
EASTERN GULF OF ALASKA
1
EGA
1.0
area
8
3.4   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-145.00 59.00
-140.00 59.50
-138.50 59.00
-137.00 58.00
-136.75 57.50
-141.00 56.50
-145.00 56.50
4.75  7.9 7.6 8.2
1
20316.14  2.0392  25399.62  2.1186  16518.40  1.9599   !created
20/09/95
FLATHEAD LAKE
1
FHL
1.0
area
4
4.0   4.8   5.3   5.8
1960  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-114.900  48.600
-114.000  48.600
-112.200  47.000
-114.800  47.000
4.75  7.1 7.3 7.5
1
6064.676000 2.237000  26533.883000 2.656000  111693.594000
3.075000 !created 20/09/95
GEORGIA STRAIT
1
GEO         (deep)
1.0
area
7
2.0   2.3   2.8   4.8   5.3   5.8   6.8
1982  1976  1956  1940  1917  1899  1860
50.0  !Depth
```

```
   4
-124.60 50.75
-122.70 49.33
-123.84 48.88
-125.70 50.27
4.75  7.0 6.5 7.3
1 3 4 0.3 5 0.4 6 0.3
66.91  2.2711  117.93  2.7856  28.03  1.7566   !created 20/09/95
GLACIER BAY
1
GLB
1.0
area
8
2.8   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   6
-136.50 59.60
-136.00 59.30
-135.70 59.00
-135.70 58.75
-136.60 58.40
-138.00 59.33
4.75  7.0 6.7 7.3
1
896.47  1.7544  1153.34  1.8849  682.50  1.6239   !created 20/09/95
HECATE STRAIT
1
HEC
1.0
area
7
2.0   2.8   3.3   3.8   5.3   5.8   6.8
1986  1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-131.00 54.50
-130.20 52.00
-131.00 52.00
-133.72 54.51
4.75  7.0 6.7 7.3
1
1132.47  2.0558  1323.60  2.1672  1009.03  1.9444   !created 20/09/95
JUAN DE FUCA BENDING
1
JDF
1.0
area
7
2.0   2.8   3.8   4.8   5.3   5.8   6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   8
-127.20 49.33
-126.60 49.33
-126.60 49.90
-125.70 50.27
-123.84 48.88
-123.35 47.00
-125.50 47.00
-125.80 48.00
4.75  7.3 7.2 7.4
1
423.86  1.9707  503.34  2.1010  364.22  1.8404   !created 20/09/95
McKENZIE MOUNTAINS
1
MCK
1.0
area
8
3.2   3.3   3.8   4.8   5.3   5.8   6.3   7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   11
-136.00 65.70
-134.00 65.70
-125.00 65.70
-123.00 64.00
-123.00 60.00
-126.30 59.00
-129.00 61.00
-133.00 63.50
-137.50 63.50
-137.50 65.00
-139.00 65.70
4.75  7.2 6.9 7.5
1
35815.17  2.2054  44670.69  2.2762  30775.68  2.1347   !created
20/09/95
NORTHERN COAST MOUNTAINS
1
NCM
1.0
area
8
3.6   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-135.00 60.00
-131.55 57.67
-133.55 57.00
-135.00 58.00
-135.70 58.75
-135.70 59.00
-135.50 59.80
4.75  7.0 6.7 7.3
1
333.94  1.7908  1142.79  2.2519  78.41  1.3298   !created 20/09/95
NORTHEASTERN ALASKA
1
NEA
1.0
area
8
3.0   3.3   4.3   4.8   5.3   5.8   6.3   7.2
1985  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   7
-143.00 68.50
-139.00 67.00
-139.00 65.70
-141.00 65.00
```

```
-141.00 64.00
-145.00 65.00
-145.00 68.50
4.75  7.0 6.7 7.3
1
2555.64  2.1988  4567.81  2.4627  1262.61  1.9349   !created 20/09/95
NORTHERN FOOTHILLS
1
NFT
1.0
area
5
2.9   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   7
-123.00 60.00
-115.00 57.00
-115.00 55.00
-116.00 54.00
-119.50 53.75
-122.00 55.00
-126.30 59.00
4.75  7.0 6.7 7.3
1
2757.76  2.7926  13842.16  3.4304  619.38  2.1549   !created 20/09/95
NORTHERN JUAN DE FUCA PLATE
1
NJFP
1.0
area
4
3.0   3.3   5.3   6.8
1982  1965  1917  1899
2.90  !JB-pseudo_depth
   5
-127.20 49.33
-125.80 48.00
-125.50 47.00
-128.00 47.20
-128.00 48.90
4.75  6.8 6.6 7.0
1
22.56  1.2477  48.75  1.5574  13.03  0.9380   !created 20/09/95
NORTHERN JUAN DE FUCA RIDGE
1
NJFR
1.0
area
3
4.1   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   4
-128.00 48.40
-128.00 47.20
-129.50 47.20
-129.50 48.40
4.75  6.0 5.5 6.5
1
47690.44  2.6681  560310.19  3.3228  3856.19  2.0134   !created
20/09/95
NOOTKA FAULT
1
NOF
1.0
area
7
2.0   2.8   3.3   3.8   4.8   5.3   6.8
1982  1962  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   9
-127.85 49.72
-127.50 50.00
-126.90 50.00
-126.60 49.90
-126.60 49.33
-127.20 49.33
-128.00 48.90
-128.10 48.90
-128.10 49.10
4.75  7.0 6.7 7.3
1
368.53  1.7302  433.60  1.8238  347.70  1.6366   !created 20/09/95
NORTHERN ROCKY MOUNTAIN TRENCH
1
NRMT
1.0
area
5
2.5   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   6
-129.00 61.00
-126.30 59.00
-122.00 55.00
-119.50 53.75
-122.50 53.50
-130.00 60.00
4.75  7.0 6.7 7.3
1
278.62  2.0912  558.80  2.4389  156.85  1.7436   !created 20/09/95
OGILVIE MOUTAINS
1
OGL
1.0
area
8
3.0   3.3   4.3   4.8   5.3   5.8   6.3   7.2
1985  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   6
-139.00 65.70
-137.50 65.00
-137.50 63.50
-139.00 63.50
-141.00 64.00
-141.00 65.00
4.75  7.0 6.7 7.3
1
318.14  1.6921  646.53  1.9550  193.82  1.4292   !created 20/09/95
PUGET SOUND        ! MODIFIED
1
```

```
PUG         (deep)
1.0
area
7
2.2   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
50.0  !Depth
   6
-122.70 49.33
-122.30 49.00
-122.00 48.00
-122.00 47.00
-123.35 47.00
-123.84 48.88
4.75  7.3 7.1 7.6
1 3 4 0.3 5 0.4 6 0.3
18.1  1.01 19.9 1.12  16.4 0.90 !modified 15/12/95
QUEEN CHARLOTTE FAULT BORDER
1
QCB
1.0
area
6
3.0   3.3   4.3   5.3   5.8   6.8
1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   7
-136.75 57.50
-136.00 55.50
-133.75 53.00
-132.00 51.50
-134.00 50.50
-138.00 54.00
-139.00 56.95
4.75  7.0 6.7 7.3
1
363.97  1.9619  1101.62  2.3947  140.58  1.5291 !created 20/09/95
QUEEN CHARLOTTE FAULT
1
QCF
1.0
fault
90.0 90.0 3 10.0 25.0
-1.085  0.389  0.01
3
-136.80  58.70
-132.40  52.90
-130.60  51.50
4.75  8.2 8.5 8.7
1
829.029000 1.431000  977.199000 1.510000  1146.396000 1.589000
!created 20/09/95
QUEEN CHARLOTTE SOUND
1
QCS
1.0
area
4
3.0   3.3   5.3   6.8
1983  1965  1917  1899
2.90  !JB-pseudo_depth
   6
-130.20 52.00
-128.21 50.21
-128.43 50.08
-130.00 51.00
-130.30 51.50
-131.00 52.00
4.75  7.0 6.7 7.3
1
72.73  1.4292  131.09  1.6718  47.41  1.1867   !created 20/09/95
REVERE-DELLWOOD, SOVANCO
1
RDS
1.0
area
3
3.3   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   10
-130.30 51.50
-130.00 51.00
-128.43 50.08
-127.85 49.72
-128.10 49.10
-128.10 48.90
-128.00 48.90
-128.00 48.40
-130.00 48.40
-132.00 51.50
4.75  7.0 6.8 7.2
1
2443.76  1.4599  2824.63  1.5088  2226.72  1.4110   !created
20/09/95
RICHARDSON MOUNTAINS
1
RIC
1.0
area
8
3.0   3.3   3.8   4.8   5.3   5.8   6.3   7.2
1982  1969  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   4
-135.00 67.30
-134.00 65.70
-136.00 65.70
-137.00 67.30
4.75  7.0 6.7 7.3
1
3519.08  2.0631  4797.84  2.2094  2392.91  1.9169   !created
20/09/95
SOUTHERN COAST MOUNTAINS
1
SCM         (shallow)
1.0
area
8
2.0   2.3   2.8   3.3   4.8   5.3   5.8   7.2
1982  1976  1962  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   10
-126.60 49.90
```

```
-126.90 50.00
-127.50 50.00
-127.75 50.33
-125.00 51.50
-124.50 51.50
-122.00 50.00
-121.83 49.65
-123.84 48.88
-125.70 50.27
4.75  7.0 6.5 7.3
1
129.59  1.7003  153.52  1.8461  108.12  1.5546 !created 20/09/95
SOUTHEASTERN BRITISH COLUMBIA
1
SEBC
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
1966  1965  1960  1940  1917  1899
2.90  !JB-pseudo_depth
   6
-119.50 53.75
-112.75 48.00
-121.00 48.00
-122.00 50.00
-124.50 51.50
-122.50 53.50
4.75  7.0 6.7 7.3
1
854.77  1.8125  1168.50  1.9479  634.06  1.6772   !created 20/09/95
SOUTHERN FOOTHILLS
1
SFT
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
1966  1965  1960  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-116.00 54.00
-114.00 52.00
-111.00 48.00
-112.75 48.00
-119.50 53.75
4.75  6.0 5.0 7.0
1
4878.34  2.4781  9370.34  2.7375  2514.87  2.2186   !created 20/09/95
SOUTHERN YUKON TERRITORY
1
SYT
1.0
area
8
3.0   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   9
-141.00 64.00
-139.00 63.50
-133.00 63.50
-129.00 61.00
-130.00 60.00
-135.00 60.00
-135.50 59.80
-140.00 62.00
-141.00 62.40
4.75  7.0 6.7 7.3
1
529.50  1.9283  1050.45  2.2452 239.13  1.6114   !created 20/09/95
YAKUTAT FAIRWEATHER FAULT
1
YFF
1.0
area
8
3.4   3.8   4.3   4.8   5.3   5.8   6.3   7.2
1979  1972  1965  1962  1951  1935  1917  1899
2.90  !JB-pseudo_depth
   11
-145.00 61.00
-141.00 61.00
-139.00 60.50
-138.00 59.67
-138.00 59.33
-136.60 58.40
-136.40 58.24
-137.00 58.00
-138.50 59.00
-140.00 59.50
-145.00 59.00
4.75  8.5 8.2 8.7
1
27728.38  2.1288  35213.07  2.2119 22338.68  2.0457 !created
20/09/95
```

```
PSA 1.0 sec WEST R model deep-Youngs etal97
Probilities of Exceedence for INTERP Subroutine in GSCFRISK.
4  0.01  0.0021  0.001 0.000404
Data Set for Integrations in GSCFRISK.
6 50 5.0 5.0 0.10 4 2
24  1. 3. 10. 13.5 17.5 23.5 30. 42. 60. 75. 100. 135. 175. 235. 300.
420. 600. 750. 1000. 1350. 1750. 2350. 3000. 4200.
3 1 0.3 2 0.4 3 0.3
B
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3
declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3
declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) + 0.7 nat
log
-1.036  -0.0064   -2.234 1.45   -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s)
-1.736  -0.0064   -2.234 1.45   -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) - 0.7 nat
log
-2.436  -0.0064   -2.234 1.45   -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
1 1.0
ROGERS' 1991 SOURCE ZONES - GR91
26  3  3  1  26  11
0.68  0.16  0.16
0.68  0.16  0.16
1.0
1  1  1  1
ALASKA COASTAL
1
ALC
1.0
area
****************************************
Borrowed from USGS; No Completeness Data.
****************************************
2.90  !JB-pseudo_depth
4
-145.000  61.000
-145.000  59.300
-156.000  54.700
-157.500  55.800
4.75  8.5 8.2 8.7
1
3848.1 1.43  5731.25 1.51 2585.08 1.35
ALASKA INLAND
1
ALI
1.0
area
****************************************
Borrowed from USGS; No Completeness Data.
****************************************
2.90  !JB-pseudo_depth
7
-145.000  64.500
-145.000  61.000
-157.500  55.800
-160.000  54.300
-160.000  57.000
-154.000  60.000
-151.000  64.500
4.75  8.5 8.2 8.5
1
57235.7 1.73  99129.5 1.84 33058.6 1.62
BEAUFORT SEA
1
BFT
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   4
-137.800  72.800
-128.700  72.800
-130.900  70.600
-138.600  71.100
4.75  7.0 6.7 7.3
1
622.72  1.6935  853.62  1.8624  393.90  1.5246   !created 25/09/95
BROOKS PENINSULA
1
BRO
1.0
area
6
2.0   3.3   3.8   4.8   5.3   6.8
1982  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-127.740  50.330
-127.300  50.150
-127.630  49.980
-128.000  50.180
4.75  7.0 6.7 7.3
1
8.03  1.0635  8.75  1.2636  6.58  0.8634 !created 25/09/95
CASCADE MOUNTAINS - MODIFIED!
1
CAS         (shallow)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   7.3
1976  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   10
-123.600  51.900
-122.000  51.200
-120.000  48.700
-120.000  47.000
-124.030  47.000
-123.900  47.560
-124.230  48.030
-126.710  49.540
-126.400  49.740
-126.710  49.910
4.75  7.7 7.7 7.7
```

```
1
14.6 0.85 1222. 1.86 14.6 0.85 ! updated 05/12/95
COASTAL
1
CST
1.0
area
5
3.6   4.3   5.3   5.8   6.8
1972  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   10
-136.800  58.700
-135.100  60.000
-127.100  53.100
-123.600  51.900
-126.710  49.910
-130.600  51.500
-131.180  51.950
-129.700  52.600
-131.500  54.400
-133.480  54.500
4.75  7.5 7.4 7.6
1
317.50  1.5519  563.97  1.7649  177.69  1.3389 !created 25/09/95
DENALI
1
DEN
1.0
area
7
3.0   3.8   4.3   4.8   5.3   5.8   6.3
1979  1972  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   6
-145.000  63.100
-145.000  64.000
-139.300  62.000
-135.500  59.700
-136.800  58.700
-140.700  61.200
4.75  7.0 6.7 7.3
1
3903.02  1.8681  4836.25  1.9607  3182.29  1.7755   !created 25/09/95
EXPLORER PLATE BENDING
1
EXP
1.0
area
4
3.0   3.3   5.3   6.8
1983  1965  1917  1899
2.90  !JB-pseudo_depth
   8
-130.600  51.500
-127.740  50.330
-128.000  50.180
-127.630  49.980
-127.300  50.150
-127.090  50.070
-127.750  49.640
-130.900  51.330
4.75  7.0 6.7 7.3
1
103.32  1.3007  160.40  1.4544  85.62  1.1469 !created 25/09/95
FLATHEAD LAKE
1
FHL
1.0
area
4
4.0   4.8   5.3   5.8
1960  1940  1917  1899
2.90  !JB-pseudo_depth
   4
-114.900  48.600
-114.000  48.600
-112.200  47.000
-114.800  47.000
4.75  7.3 7.1 7.5
1
14016.75  2.4905  63130.85  2.9255  3021.55  2.0554 !created
25/09/95
GULF OF ALASKA
1
GOA
1.0
area
7
4.0   4.3   4.8   5.3   5.8   6.3   7.3
1972  1965  1961  1951  1935  1917  1850
2.90  !JB-pseudo_depth
   4
-143.600  59.500
-142.000  59.400
-142.300  56.700
-144.000  56.700
4.75  7.8 7.6 8.0
1
49696.31  2.3124  86255.05  2.4729  28865.38  2.1519 !created
25/09/95
GEORGIA STRAIT/PUGET SOUND MODIFIED!
1
GSP         (deep)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1976  1970  1956  1940  1917  1899  1860
50.0  !Depth
   10
-123.850  49.550
-122.400  48.840
-121.720  48.300
-121.500  47.680
-121.700  47.000
-123.300  47.000
-123.220  47.530
-123.350  47.870
-123.830  48.250
-124.750  48.850
4.75  7.1 6.9 7.3
1 3 4 0.3 5 0.4 6 0.3
29.1 1.12 35.4 1.25 25.0 0.99  ! update 05/12/95
```

```
HECATE STRAIT
1
HEC
1.0
area
7
2.0   2.8   3.3   3.8   5.3   5.8   6.8
1986  1985  1971  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-133.480  54.500
-131.500  54.400
-129.700  52.600
-131.180  51.950
-132.400  52.900
4.75  7.0 6.7 7.3
1
1187.04  1.9660  1358.58  2.0597  1088.72  1.8722 !created 25/09/95
JUAN DE FUCA PLATE BENDING, OFFSHORE
1
JDFF
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   8
-126.710  49.540
-124.230  48.030
-123.900  47.560
-124.030  47.000
-124.900  47.000
-124.920  47.380
-125.800  48.320
-127.180  49.240
4.75  7.0 6.7 7.3
1
91.00  1.8665  175.26  2.2560  42.63  1.4770 !created 25/09/95
JUAN DE FUCA PLATE BENDING, ONSHORE
1
JDFN        (deep)
1.0
area
7
2.5   2.8   3.8   4.8   5.3   5.8   6.8
1982  1970  1956  1940  1917  1899  1860
2.90  !JB-pseudo_depth
   10
-126.400  49.740
-124.750  48.850
-123.830  48.250
-123.350  47.870
-123.220  47.530
-123.300  47.000
-124.030  47.000
-123.900  47.560
-124.230  48.030
-126.710  49.540
4.75  7.1 6.7 7.3
1
109.71  2.0692  264.78  2.5773  39.77  1.5610 !created 25/09/95
```

```
MACKENZIE MOUNTAINS
1
MMB
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   9
-132.800  65.600
-127.000  65.800
-123.600  64.400
-123.100  62.200
-124.800  59.400
-129.100  59.900
-128.700  62.300
-130.300  63.700
-133.000  64.200
4.75  7.1 6.9 7.3
1
58008.89  2.4285  72700.01  2.5043  49997.28  2.3528 !created
25/09/95
NORTHERN BC
1
NBC
1.0
area
4
3.0   3.3   5.3   5.8
1982  1965  1940  1917
2.90  !JB-pseudo_depth
   7
-135.100  60.000
-132.800  60.300
-129.000  59.900
-122.100  54.100
-120.600  53.400
-123.600  51.900
-127.100  53.100
4.75  6.0 5.7 6.3
1
22787.46  3.1989  67166.48  3.7311  4205.13  2.6667 !created
25/09/95
NOOTKA FAULT
1
NOF
1.0
area
6
2.0   3.3   3.8   4.8   5.3   6.8
1982  1965  1956  1940  1917  1899
2.90  !JB-pseudo_depth
   5
-127.090  50.070
-126.710  49.910
-126.400  49.740
-127.930  48.760
-128.500  49.150
4.75  7.0 6.7 7.3
1
458.64  1.7300  522.08  1.8177  428.11  1.6424 !created 25/09/95
```

```
NORTHERN YUKON
1
NYK
1.0
area
5
4.2   4.8   5.3   5.8   6.8
1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   8
-145.000  70.800
-134.400  69.200
-135.000  67.400
-136.500  67.400
-136.300  66.100
-134.900  64.230
-140.200  64.300
-145.000  65.000
4.75  7.0 6.7 7.3
1
7080982.50 3.7503  70270912.0 4.3478  697501.56  3.1528 !created
25/09/95
OFFSHORE
1
OFS
1.0
area
3
4.3   5.3   6.8
1965  1917  1899
2.90  !JB-pseudo_depth
   7
-130.900  51.330
-127.750  49.640
-128.500  49.150
-127.930  48.760
-128.200  47.350
-129.500  47.350
-131.500  51.000
4.75  7.1 6.9 7.3
1
46683.91  2.1010  73246.15  2.2212  30343.13  1.9808 !created
25/09/95
QUEEN CHARLOTTE FAULT
1
QCF
1.0
fault
90.0 90.0 3 10.0 25.0
-1.085  0.389  0.01
3
-136.80  58.70
-132.40  52.90
-130.60  51.50
4.75  8.5 8.2 8.5
1
1529.57  1.5454  1829.25  1.6122  1387.51  1.4787 !created 25/09/95
RICHARDSON MTNS-NORTH
1
RMN
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   5
-136.500  67.400
-135.000  67.400
-132.800  65.600
-136.170  65.930
-136.300  66.100
4.75  7.0 6.7 7.3
1
2918.86  1.9990  3948.71  2.1410  2016.90  1.8570 !created
25/09/95
RICHARDSON MTNS-SOUTH
1
RMS
1.0
area
7
3.0   3.3   3.8   4.8   5.3   5.8   6.8
1982  1969  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   4
-132.800  65.600
-133.000  64.200
-134.900  64.230
-136.170  65.930
4.75  7.0 6.7 7.3
1
1248.33  1.6684  1540.54  1.7767  945.32  1.5601 !created 25/09/95
ROCKY MOUNTAIN F and T BELT
1
ROC
1.0
area
5
3.0   3.3   5.3   5.8   6.8
1982  1965  1940  1917  1899
2.90  !JB-pseudo_depth
   11
-129.000  59.900
-124.800  59.400
-122.600  56.600
-118.400  54.400
-115.200  52.300
-114.000  49.500
-112.000  48.000
-113.330  48.000
-114.000  48.600
-120.600  53.400
-122.100  54.100
4.75  7.0 6.7 7.3
1
1560.44  2.0359  2557.10  2.2501  883.21  1.8217 !created 25/09/95
SOUTHERN BC
1
SBC
1.0
area
6
3.0   3.3   4.3   4.8   5.3   5.8
```

```
1966  1965  1960  1940  1917  1899                                          25/09/95
2.90  !JB-pseudo_depth
   8
-123.600  51.900
-120.600  53.400
-114.000  48.600
-114.900  48.600
-114.870  48.130
-120.000  48.100
-120.000  48.700
-122.000  51.200
4.75  7.0 6.7 7.3
1
1384.70  2.2082  2787.43  2.4950  673.48  1.9215 !created 25/09/95
SOUTHERN YUKON
1
SOY
1.0
area
7
3.0   3.8   4.3   4.8   5.3   5.8   6.3
1979  1972  1965  1961  1951  1935  1917
2.90  !JB-pseudo_depth
   11
-145.000  65.000
-140.200  64.300
-133.000  64.200
-130.300  63.700
-128.700  62.300
-129.100  59.900
-132.800  60.300
-135.100  60.000
-135.500  59.700
-139.300  62.000
-145.000  64.000
4.75  7.0 6.7 7.3
1
1690.75  2.1476  3157.32  2.4208  853.36  1.8744 !created 25/09/95
YAKATAT COLLISION
1
YAK
1.0
area
8
3.0   3.8   4.3   4.8   5.3   5.8   6.3   7.3
1979  1972  1965  1961  1957  1935  1917  1850
2.90  !JB-pseudo_depth
   11
-145.000  59.500
-145.000  63.100
-140.700  61.200
-140.000  60.750
-140.000  60.000
-137.800  58.200
-136.600  56.800
-142.100  58.700
-142.000  59.400
-143.600  59.500
-143.700  59.100
4.75  8.5 8.2 8.7
1
16307.38  2.0096  18689.91  2.0681  14305.26  1.9511 !created
```

Strong Ground Motion Parameters used for each period for which hazard has been calculated

```
Eastern Attenuation coefficients
AB95R PGA Median grd motion for Peak ACCEL ATKINSON BOORE 1995R mag
3.79 0.298 -0.0536 -0.00135 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PGA L  grd motion for PGA ATKINSON BOORE 1995R  mag Lower Limit
3.41 0.298 -0.0536 -0.00135 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PGA U  grd motion for PGA ATKINSON BOORE 1995R  mag Upper Limit
3.92 0.298 -0.0536 -0.00135 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PGV  Median grd motion for Peak Velocity ATKINSON BOORE 1995 R
2.04 0.422 -0.0373 0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PGV L Median grd motion for PGV ATKINSON BOORE 1995 R Lower limit
1.80 0.422 -0.0373 0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PGV U Median grd motion for PGV ATKINSON BOORE 1995 R Upper limit
2.46 0.422 -0.0373 0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

A95 PSA 0.1s  Median grd motion for Pseudo Acc 0.1s ATKINSON BOORE 1995
3.99 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
A95 PSA 0.1s  L grd motion for PSA 0.1s ATKINSON BOORE 1995 L limit
3.61 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
A95 PSA 0.1s  U grd motion for PSA 0.1s ATKINSON BOORE 1995 U limit
4.12 0.360 -0.0527 -0.00121 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.15s  Median grd motion for Pseudo Acc 0.15s ATKINSON BOORE 1995
3.85 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.15s  L grd motion for PSA 0.15s ATKINSON BOORE 1995 Lower lim
3.50 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.15s  U grd motion for PSA 0.15s ATKINSON BOORE 1995 Upper lim
4.05 0.394 -0.0595 -0.000769 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.2s  Median grd motion for Pseudo Acc 0.2s ATKINSON BOORE 1995
3.75 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.2s  L grd motion for PSA 0.2s ATKINSON BOORE 1995 Lower limit
3.43 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.2s  U grd motion for PSA 0.2s ATKINSON BOORE 1995 Upper limit
4.00 0.418 -0.0644 -0.000457 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.3s  Median grd motion for Pseudo Acc 0.3s ATKINSON BOORE 1995
3.54 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.3s  L grd motion for PSA 0.3s ATKINSON BOORE 1995 Lower limit
3.26 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.3s  U grd motion for PSA 0.3s ATKINSON BOORE 1995 Upper limit
3.88 0.475 -0.0717 -0.000106 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.4s  Median grd motion for Pseudo Acc 0.4s ATKINSON BOORE 1995
3.38 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.4s  L grd motion for PSA 0.4s ATKINSON BOORE 1995 Lower limit
3.12 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.4s  U grd motion for PSA 0.4s ATKINSON BOORE 1995 Upper limit
3.77 0.517 -0.0674 -0.000046 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 0.5s  Median grd motion for Pseudo Acc 0.5s ATKINSON BOORE 1995
3.26 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.5s  L grd motion for PSA 0.5s ATKINSON BOORE 1995 Lower limit
3.02 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 0.5s  U grd motion for PSA 0.5s ATKINSON BOORE 1995 Upper limit
3.68 0.550 -0.0640  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0

AB95R PSA 1s  Median grd motion for PSA1.0s ATKINSON BOORE 1995
2.77 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s  L grd motion for PSA1.0s ATKINSON BOORE 1995 L limit
2.59 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
AB95R PSA 1s  U grd motion for PSA1.0s ATKINSON BOORE 1995 U limit
3.31 0.620 -0.0409  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
```

```
AB95R PSA 2s  Median grd motion for Pseudo Acc 2 sec ATKINSON BOORE 1995
2.27 0.634 -0.0170  0.000 0.0 0.0 0.0 0.0 0.0 6 0.69 0.0 0.0
```

Western Attenuation coefficients

```
Boore/Joyner/Fumal(1993) Attenuation; PGA + 0.7 nat log or 0.3 dec log.
2.195 0.229 0.0 -0.00326 -0.778 0.162 5.57 0.0 0.0 11 0.529 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PGA
1.895 0.229 0.0 -0.00326 -0.778 0.162 5.57 0.0 0.0 11 0.529 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PGA - 0.7 nat log or 0.3 dec log.
1.595 0.229 0.0 -0.00326 -0.778 0.162 5.57 0.0 0.0 11 0.529 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s) + 0.7 log nat or 0.3 dec log
3.751 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s)
3.451 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.1s) - 0.7 log nat or 0.3 dec log
3.151 0.327 -0.098 -0.00395 -0.934 0.046 6.27 0.0 0.0 11 0.479 0.0 0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s) + 0.7 log nat or 0.3 dec log
3.814 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s)
3.514 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.15s) - 0.7 log nat or 0.3 dec log
3.214 0.305 -0.099 -0.00309 -0.937 0.140 7.23 0.0 0.0 11 0.486 0.0 0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s) + 0.7 log nat or 0.3 dec log
3.764 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s)
3.464 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.2s) - 0.7 log nat or 0.3 dec log
3.164 0.309 -0.090 -0.00259 -0.924 0.190 7.02 0.0 0.0 11 0.495 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s) + 0.7 log nat or 0.3 dec log
3.595 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s)
3.295 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.3s) - 0.7 log nat or 0.3 dec log
2.995 0.334 -0.070 -0.00202 -0.893 0.239 5.94 0.0 0.0 11 0.520 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s) + 0.7 log nat or 0.3 dec log
3.426 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s)
3.126 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.4s) - 0.7 log nat or 0.3 dec log
2.826 0.361 -0.052 -0.00170 -0.867 0.264 4.91 0.0 0.0 11 0.543 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s) + 0.7 log nat or 0.3 dec log
3.280 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s)
2.980 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (0.5s) - 0.7 log nat or 0.3 dec log
2.680 0.384 -0.039 -0.00148 -0.846 0.279 4.13 0.0 0.0 11 0.562 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s + 0.7 natlog or 0.3 declog
2.822 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s
2.522 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA1.0s - 0.7 natlog or 0.3 declog
2.222 0.450 -0.014 -0.00097 -0.798 0.314 2.90 0.0 0.0 11 0.622 0 0.0

Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s) + 0.7 log nat or 0.3 dec log
2.534 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s)
2.234 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
Boore/Joyner/Fumal(1993) Attenuation; PSA (2.0s) - 0.7 log nat or 0.3 dec log
1.934 0.471 -0.037 -0.00064 -0.812 0.360 5.85 0.0 0.0 11 0.675 0 0.0
```

Youngs intraslab earthquake relations, used for deep zones (earthquake depth = 50)

```
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PGA + 0.7 nat log
0.70  0.0   -2.552 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PGA
0.0   0.0   -2.552 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PGA - 0.7 nat log
-0.70 0.0   -2.552 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.1s) + 0.7 nat log
1.818   -0.0011  -2.655 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.1s)
1.118   -0.0011  -2.655 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.1s) - 0.7 nat log
0.418   -0.0011  -2.655 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

PSA 0.15 (VALUES INTERP BY CUBIC SPLINE - D WEICHERT)
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.15s) + 0.7 nat log
1.667   -0.002028  -2.583 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.15s)
0.967   -0.002028  -2.583 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.15s) - 0.7 nat log
0.267   -0.002028  -2.583 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.2s) + 0.7 nat log
1.422   -0.0027  -2.528 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.2s)
0.722   -0.0027  -2.528 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.2s) - 0.7 nat log
0.022   -0.0027  -2.528 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.3s) + 0.7 nat log
0.946   -0.0036  -2.454 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.3s)
0.246   -0.0036  -2.454 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.3s) - 0.7 nat log
-0.454  -0.0036  -2.454 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.4s) + 0.7 nat log
0.585   -0.0043   -2.401 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.4s)
-0.115  -0.0043   -2.401 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.4s) - 0.7 nat log
-0.815  -0.0043   -2.401 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.5s) + 0.7 nat log
0.300   -0.0048   -2.360 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.5s)
-0.400  -0.0048   -2.360 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (0.5s) - 0.7 nat log
-1.100  -0.0048   -2.360 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) + 0.7 nat log
-1.036  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s)
-1.736  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (1.0s) - 0.7 nat log
-2.436  -0.0064   -2.234 1.45  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50

Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (2.0s) + 0.7 nat log
-2.628  -0.0080   -2.107 1.55  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (2.0s)
-3.328  -0.0080   -2.107 1.55  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
Youngs, Chiou, Silva, Humphrey (1997) INTRASLAB PSA (2.0s) - 0.7 nat log
-4.028  -0.0080   -2.107 1.55  -0.1 1.0 0.0 0.0 0.0 13 0.0 0 0.0 50
```

Youngs interface earthquake relations used for Cascadia scenario, earthquake depth = 25

```
Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PGA
0.0   0.0   -2.552 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.1s)
1.118   -0.0011  -2.655 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.15s)
0.955   -0.0019  -2.592 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.2s)
0.722   -0.0027  -2.528 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.3s)
0.246   -0.0036  -2.454 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.4s)
-0.115  -0.0043   -2.401 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (0.5s)
-0.400  -0.0048   -2.360 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (1.0s)
-1.736  -0.0064   -2.234 1.45  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25

Youngs, Chiou, Silva, Humphrey (1997) INTERFACE PSA (2.0s)
-3.328  -0.0080   -2.107 1.55  -0.1 0.0 0.0 0.0 0.0 13 0.0 0 0.0 25
```

APPENDIX E

Published information relevant to the derivation of RGC factors

This Appendix includes Figure 3a and Table 7b from Boore et al., (1993) and Tables 2 and 3 from Martin and Dobry (1994) referenced in the section on "Reference Ground Condition for Canada". Tables 4.1.2.4a and 4.1.2.4b, which are the implementation of the Martin and Dobry tables in the 1997 edition of the "NEHRP recommended provisions for seismic regulations for new buildings and other structures" follow.

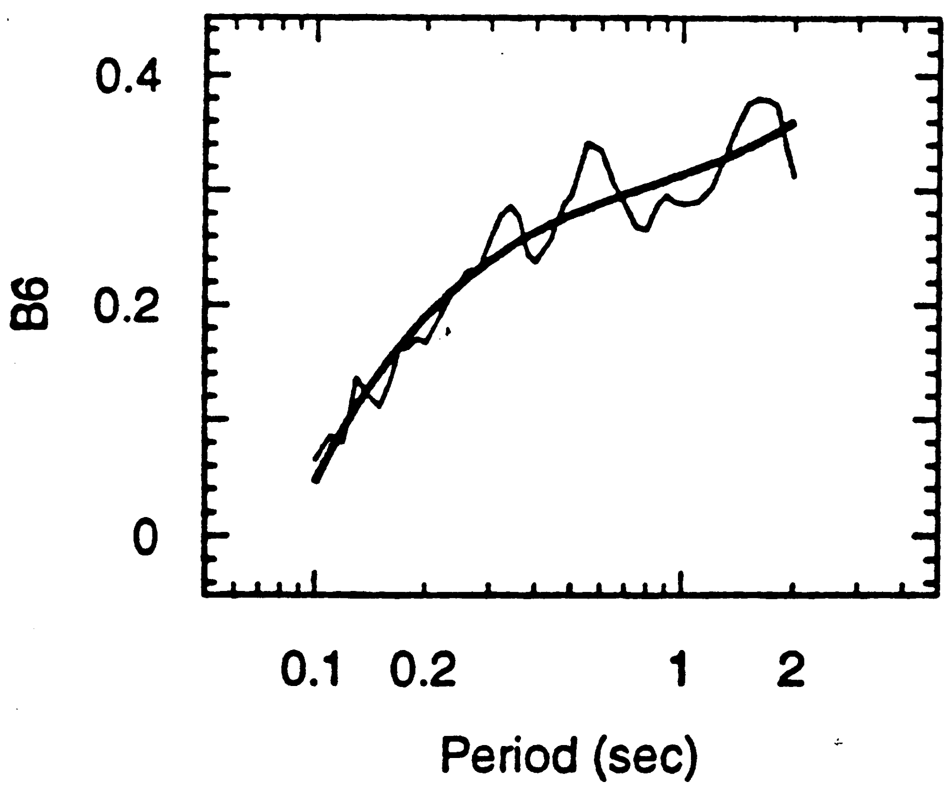


Figure 3a. The unsmoothed and smoothed coefficients (light and heavy lines, respectively) for the 5 percent damped response spectra of the random horizontal component.

Table 7b. Smoothed coefficients of equations for the random horizontal component of 5 percent damped PSV (cm/s; distance in km).

T(s)	B1	B2	B3	B4	B5	B6	B7	H	S1	SC	SR	SE	SLOGY
.10	1.653	.327	-.098	.00000	-.934	.046	.136	6.27	.191	.083	.208	.003	.208
.11	1.725	.318	-.100	.00000	-.937	.071	.156	6.65	.189	.087	.208	.005	.208
.12	1.782	.313	-.101	.00000	-.939	.093	.174	6.91	.187	.091	.208	.008	.208
.13	1.828	.309	-.101	.00000	-.939	.111	.191	7.08	.186	.094	.208	.010	.209
.14	1.864	.307	-.100	.00000	-.938	.127	.206	7.18	.185	.097	.209	.012	.209
.15	1.892	.305	-.099	.00000	-.937	.140	.221	7.23	.185	.100	.210	.015	.211
.16	1.915	.305	-.098	.00000	-.935	.153	.234	7.24	.184	.102	.210	.017	.211
.17	1.933	.305	-.096	.00000	-.933	.163	.246	7.21	.184	.104	.211	.019	.212
.18	1.948	.306	-.094	.00000	-.930	.173	.258	7.16	.184	.106	.212	.021	.213
.19	1.959	.308	-.092	.00000	-.927	.182	.269	7.10	.184	.108	.213	.023	.215
.20	1.967	.309	-.090	.00000	-.924	.190	.279	7.02	.184	.109	.214	.025	.215
.22	1.978	.313	-.086	.00000	-.918	.203	.297	6.83	.185	.112	.216	.029	.218
.24	1.982	.318	-.082	.00000	-.912	.214	.314	6.62	.185	.114	.217	.033	.220
.26	1.982	.323	-.078	.00000	-.906	.224	.329	6.39	.186	.116	.219	.036	.222
.28	1.979	.329	-.073	.00000	-.899	.232	.343	6.17	.187	.118	.221	.040	.225
.30	1.974	.334	-.070	.00000	-.893	.239	.356	5.94	.187	.120	.222	.043	.226
.32	1.967	.340	-.066	.00000	-.888	.245	.367	5.72	.188	.121	.224	.046	.228
.34	1.959	.345	-.062	.00000	-.882	.251	.378	5.50	.189	.122	.225	.048	.230
.36	1.950	.350	-.059	.00000	-.877	.256	.387	5.30	.190	.123	.226	.051	.232
.38	1.940	.356	-.055	.00000	-.872	.260	.396	5.10	.191	.125	.228	.054	.235
.40	1.930	.361	-.052	.00000	-.867	.264	.405	4.91	.192	.125	.229	.056	.236
.42	1.920	.365	-.049	.00000	-.862	.267	.413	4.74	.193	.126	.230	.058	.238
.44	1.910	.370	-.047	.00000	-.858	.271	.420	4.57	.193	.127	.231	.061	.239
.46	1.900	.375	-.044	.00000	-.854	.273	.427	4.41	.194	.128	.232	.063	.241
.48	1.890	.379	-.042	.00000	-.850	.276	.433	4.26	.195	.129	.234	.065	.243
.50	1.881	.384	-.039	.00000	-.846	.279	.439	4.13	.196	.129	.235	.067	.244
.55	1.857	.394	-.034	.00000	-.837	.284	.452	3.82	.198	.131	.237	.071	.248
.60	1.835	.403	-.030	.00000	-.830	.289	.464	3.57	.199	.133	.239	.076	.251
.65	1.815	.411	-.026	.00000	-.823	.293	.474	3.36	.201	.134	.242	.079	.254
.70	1.797	.418	-.023	.00000	-.818	.297	.483	3.20	.202	.135	.243	.083	.257
.75	1.781	.425	-.020	.00000	-.813	.300	.490	3.07	.203	.136	.244	.086	.259
.80	1.766	.431	-.018	.00000	-.809	.303	.497	2.98	.204	.137	.246	.089	.261
.85	1.753	.437	-.016	.00000	-.805	.306	.503	2.92	.205	.138	.247	.092	.264
.90	1.742	.442	-.015	.00000	-.802	.309	.508	2.89	.206	.139	.249	.095	.266
.95	1.732	.446	-.014	.00000	-.800	.312	.513	2.88	.207	.140	.250	.097	.268
1.00	1.724	.450	-.014	.00000	-.798	.314	.517	2.90	.208	.141	.251	.100	.270
1.10	1.710	.457	-.013	.00000	-.795	.319	.523	2.99	.209	.143	.253	.104	.274
1.20	1.701	.462	-.014	.00000	-.794	.324	.528	3.14	.210	.145	.255	.108	.277
1.30	1.696	.466	-.015	.00000	-.793	.328	.532	3.36	.211	.146	.257	.111	.280
1.40	1.695	.469	-.017	.00000	-.794	.333	.535	3.62	.212	.148	.259	.114	.283
1.50	1.696	.471	-.019	.00000	-.796	.338	.537	3.92	.212	.150	.260	.117	.285
1.60	1.700	.472	-.022	.00000	-.798	.342	.538	4.26	.212	.151	.260	.119	.286
1.70	1.706	.473	-.025	.00000	-.801	.347	.539	4.62	.212	.153	.261	.122	.289
1.80	1.715	.472	-.029	.00000	-.804	.351	.539	5.01	.212	.154	.262	.124	.290
1.90	1.725	.472	-.032	.00000	-.808	.356	.538	5.42	.212	.156	.263	.126	.292
2.00	1.737	.471	-.037	.00000	-.812	.360	.537	5.85	.212	.157	.264	.128	.293

The equations are to be used for 5.0 <= M <= 7.7 and d <= 100.0 km.

Table 2: Values of F_a as a function of site conditions and shaking intensity.

Shaking Intensity ⇒ Site Class ⇓	A_a = 0.1 g	A_a = 0.2 g	A_a = 0.3 g	A_a = 0.4 g	A_a = 0.5 g
(A_0)	0.8	0.8	0.8	0.8	0.8
A	1.0	1.0	1.0	1.0	1.0
B	1.2	1.2	1.1	1.0	1.0
C	1.6	1.4	1.2	1.1	1.0
D_1	2.5	1.7	1.2	0.9	(–)[1]
D_2	2.0	1.6	1.2	0.9	(–)[1]
(E)	(–)[1]	(–)[1]	(–)[1]	(–)[1]	(–)[1]

[1] Site-specific geotechnical investigations and dynamic site response analyses should be performed.

Table 3: Values of F_v as a function of site conditions and shaking intensity.

Shaking Intensity ⇒ Site Class ⇓	A_v = 0.1 g	A_v = 0.2 g	A_v = 0.3 g	A_v = 0.4 g	A_v = 0.5 g
(A_0)	0.8	0.8	0.8	0.8	0.8
A	1.0	1.0	1.0	1.0	1.0
B	1.7	1.6	1.5	1.4	1.3
C	2.4	2.0	1.8	1.6	1.5
D_1	3.5	3.2	2.8	2.4	(–)[2]
D_2	3.5	3.2	2.8	2.4	(–)[2]
(E)	(–)[2]	(–)[2]	(–)[2]	(–)[2]	(–)[2]

[2] Site-specific geotechnical investigations and dynamic site response analyses should be performed.

Tables 4.1.2.4a and 4.1.2.4b from the 1997 edition of the "NEHRP recommended provisions for seismic regulations for new buildings and other structures"are the implementation of Tables 2 and 3 from Martin and Dobry (1994).

TABLE 4.1.2.4a Values of F_a as a Function of Site Class and Mapped Short-Period Maximum Considered Earthquake Spectral Acceleration

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration at Short Periods				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	*a*
F	*a*	*a*	*a*	*a*	*a*

NOTE: Use straight line interpolation for intermediate values of S_S.
[a] Site-specific geotechnical investigation and dynamic site response analyses shall be performed.

TABLE 4.1.2.4b Values of F_v as a Function of Site Class and Mapped 1 Second Period Maximum Considered Earthquake Spectral Acceleration

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration at 1 Second Periods				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	*a*
F	*a*	*a*	*a*	*a*	*a*

NOTE: Use straight line interpolation for intermediate values of S_1.
[a] Site-specific geotechnical investigation and dynamic site response analyses shall be performed.