With special thanks to:

Users Manual for the PEER Ground Motion Database Web Application

Beta Version – October 1, 2010

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0. DISCLAIMER

The web application is based on the Design Ground Motion Library (DGML) Version 2.0, which has been custom modified and adapted for the internet interface.

Due to the possibility of human or mechanical error as well as other factors, this web-application is provided “as is” and the authors make no representation, express or implied, as to the accuracy, reliability, completeness, or timeliness of this software, and are not responsible for any loss or damages incurred by parties using this software.

Further QA/QC may be needed to ensure the quality of this database. Any comments, questions, bug reports regarding the PEER Ground Motion Database (PGMD) – Beta Version application and the Users Manual can be addressed to (email: peer_center@berkeley.edu).

All the Figures of this Users Manual were captured using a Windows 7 operating system and Google Chrome browser. Thus, if an alternative operating system and/or browser is used, the user may find small differences.

1. INTRODUCTION

The PEER Ground Motion Database – Beta Version is an interactive web based application that allows the user to select sets of strong ground motion acceleration time series that are representative of design ground motions. The user specifies the design ground motions in terms of a target response spectrum and the desired characteristics of the earthquake ground motions in terms of earthquake magnitude, source-to-site distance and other general characteristics. The PGMD tool then selects acceleration time series from the PEER-NGA database for rotated fault-normal and fault-parallel acceleration time series that satisfy the user-specified selection criteria and provide good fits to the target response spectrum.

Several features of the PEER Ground Motion Database – Beta Version are highlighted as follows:

***Graphic User Interface*:** GUI provides a user-friendly interface for data input and processing. The user’s operation involves checking boxes, selecting pop-up menus, and pushing buttons. There are numerous features that are designed to facilitate easy usage. One example is the software can automatically retrieve previously specified input data.

***Interactive Plotting*:** Results in each step can be visualized in real time, and results from different sets of input parameters can be easily compared. The software provides a list of the selected records with important information. By clicking the list, users can visually inspect the response spectrum, acceleration/velocity/displacement time-series of each individual record for each component.

Flexibility: The PGMD provides users flexibility to exercise different criteria to select the design records. Users have the options to scale or not to scale the records; to select the record according to the geometric mean of fault normal and fault parallel components. The user can choose to select records with pulses or without pulses. The number of output records can be user-specified, and users have the capacity to manually select and adjust the results to meet their specific requirement. In addition to the features provided in the previous release, PEER Ground Motion Database – Beta Version provides a supplementary search engine to allow users to search the database by NGA numbers, earthquake names, and station names. The new search engine gives users flexibility to inspect any record in the database.

Easy Output*:* The PEER Ground Motion Database – Beta Version provides easy ways to output search results, plots and tables. The web based application can automatically generate a "Target Spectrum Report" and a "Search Result Report" and save them into a Microsoft Excel spreadsheet file. The PGMD reports summarize search criteria, scale factors, scaled spectra of selected records, and other record information. The response spectra plots and time series plots can be exported into figure files of different formats. Finally, files containing acceleration time series of selected records can be saved for each project.

Efficiency: The algorithm of the PGMD web application is robust and efficient. The search engine can scan and sort the NGA database within a few seconds.

Extendibility: The PGMD web application is directly connected to the NGA flatfile and strong motion database, so it can be easily upgraded to accommodate future development of the NGA database.

2. GETTING STARTED

2.1 PGMD Basic Steps

From the PEER Ground Motion Database – Beta Version you have the option to download unscaled earthquake records as well as records that can be scaled to a target spectrum. The process of downloading unscaled earthquake records is described in Section 3.0 of the Users Manual.

There are two basic steps in the use of the downloading scaled earthquake records. Step one is the creation of the target response spectrum. The process of creating the target spectrum is described in Section 4.0 of the Users Manual. Step two is to search the PEER database for recordings that satisfy user-specified selection criteria and whose response spectra are similar to the target spectrum. Section 5.0 of the Users Manual describes the process of specifying selection criteria and developing sets of acceleration time series. A user can inspect each ground motion record to finalize the selection

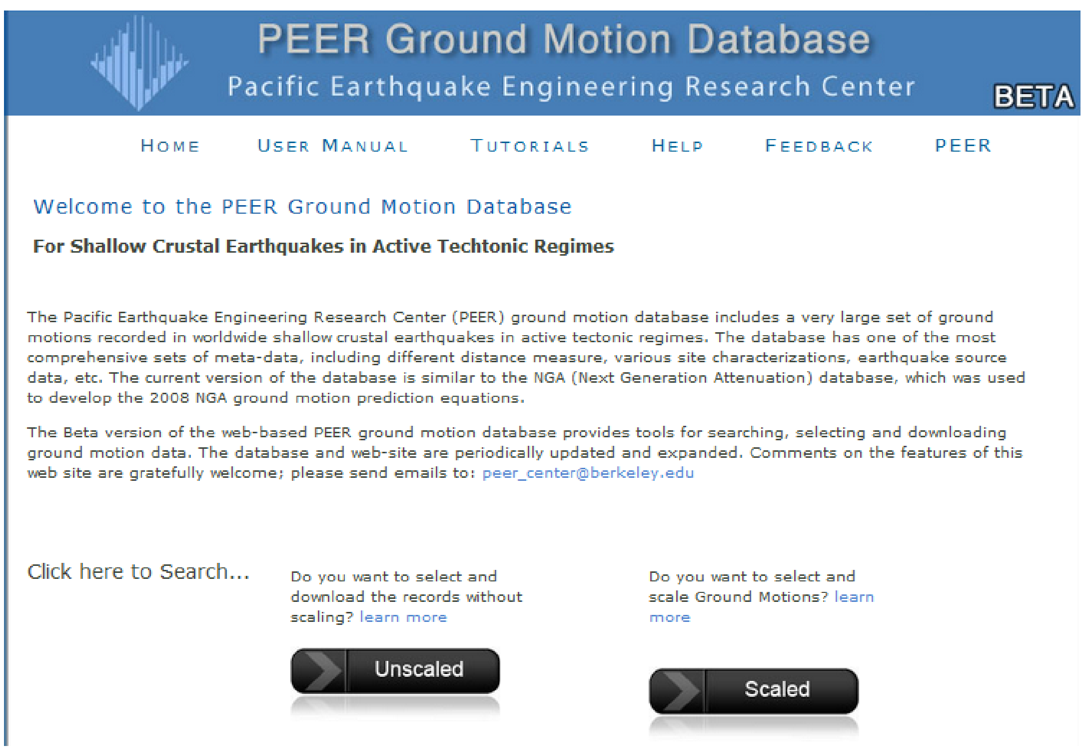

Figure 1: PGMD Home Page

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3. SEARCH PEER DATABASE - UNSCALED SECTION

The PGMD SEARCH ENGINE window for the unscaled section contains nine main parts, as labeled in Figure 2: (1) Main Search Engine; (2) Supplementary Search Engine to specify the record acceptance criteria and perform search over PEER database; (3) Spectra plotting window; (4) Ground motion record information output list; (5) Google map to display geographic location as well as basic information about each record checked; (6) Acceleration/ Velocity/ Displacement time series plotting of a selected record; (7) Zoom In time function for examining the time series of an individual record; (8) Graphic control panel for line styles and maximum number of output to be listed; (9) Buttons to save the search results and selected acceleration time series files.

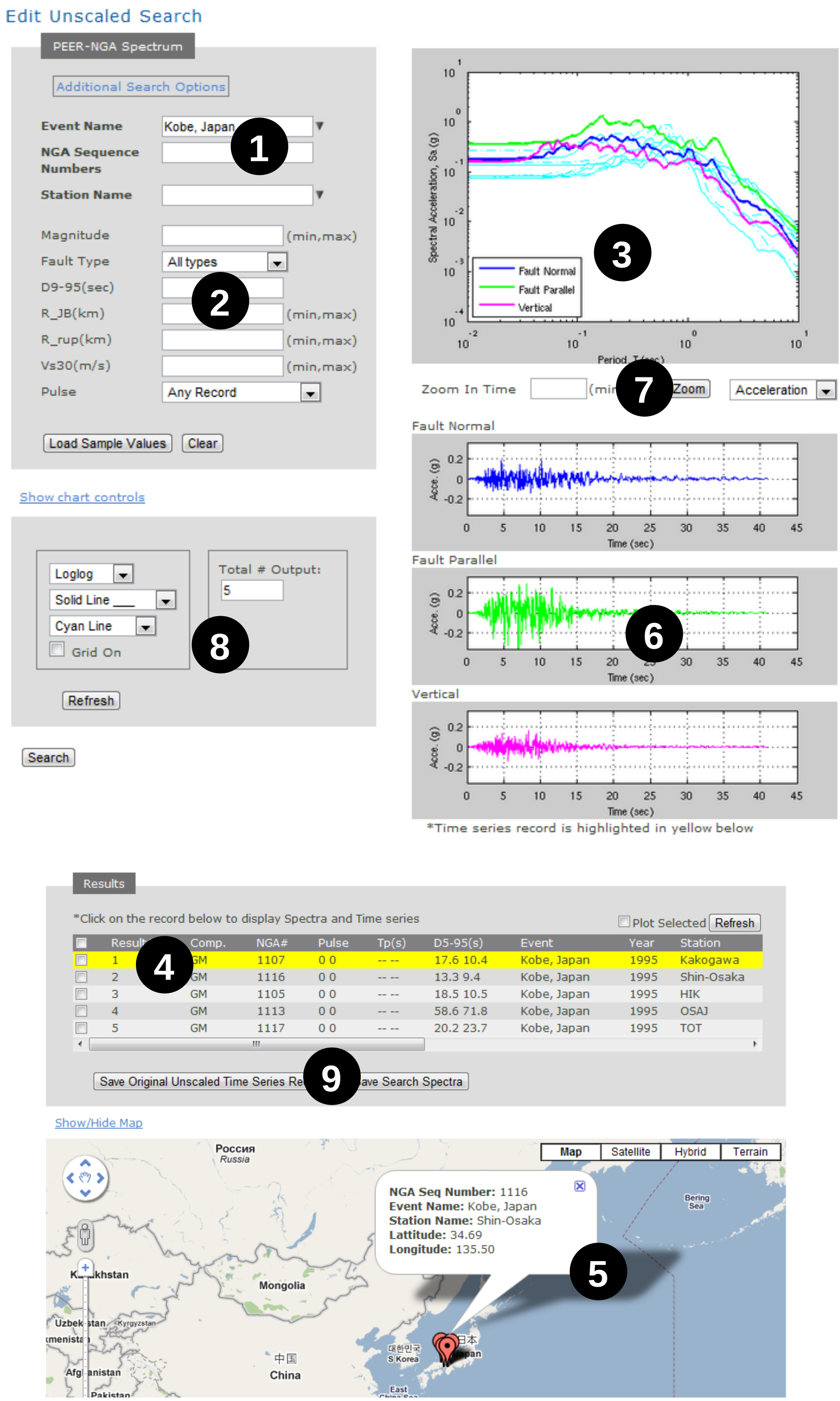


Figure 2: PGMD Search Engine Window

3.1 MAIN AND SUPPLEMENTARY SEARCH ENGINES

PGMD Beta Version provides two types of search engines. Figure 3 illustrates how to enable the refined search engine interfaces by clicking "Additional Search Options" button. The main search engine explores the database according to specified NGA sequence numbers, event names, and station names. The supplementary search engine explores the database according to the specified acceptable ranges for the characteristics of the recordings (e.g. the appropriate magnitude, distance range etc, termed as "acceptance criteria"). The two search engines are described in the following sections. By default, PGMD displays the main search engine.

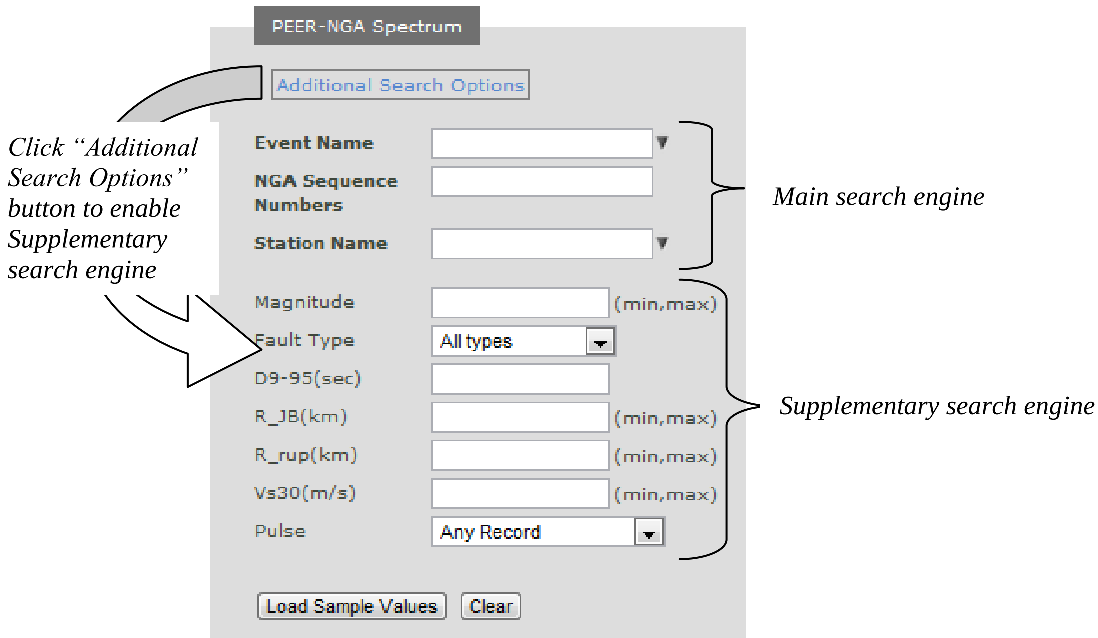


Figure 3: Main and Supplementary Search Engines

3.1.1 Main Search Engine: Search According to NGA Numbers etc.

Main Search Engine allows users to search according to specified NGA sequence numbers, event name, or station name. This feature is particularly useful for users to inspect any particular record.

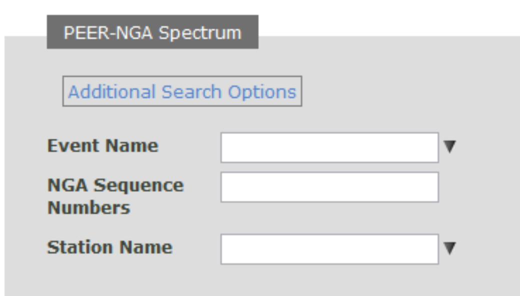


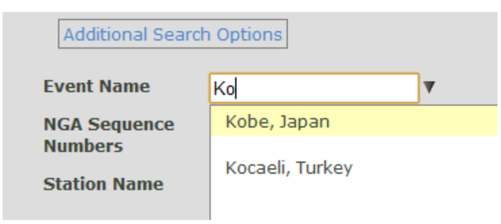
Figure 4: Main Search Engine (Default) User Interface.

Event Name and Station Name require string input (Figure 5a) or by clicking the down arrow button and selecting one of the entries (Figure 5b). The input string should be contained in the list of event names and station names as specified in NGA flatfile. For example, if user wants to search all "Kobe, Japan" records, he can begin input the first letters "Ko" and then select the record from the list. The PGMD uses exact character matching to search the records, but it won't distinguish upper- or lower-case letters.

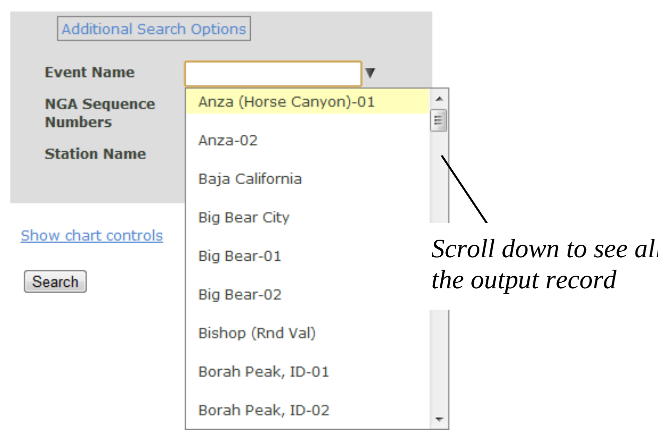
NGA sequence number is a unique number assigned to each pair of Fault Normal (FN) / Fault Parallel (FP) records in the NGA flatfile. The NGA sequence number should be positive numbers.

NGA sequence numbers can be input using the following formats: (1) number array separated by comma, eg. "250,251,252". (2) number range delimited by colon, eg. "250:260" specifies NGA number range from #250 to #260. (3) combination of format (1) and (2), eg. "250:260, 300, 700" specifies NGA numbers from #250 to #260, and #300, #700. PGMD will automatically eliminate any duplicate numbers in the NGA sequence number input.

The input boxes can be left as blank, which imposes no restriction in that field. If more than one input field is filled in, the search results are the logical "AND" of these multiple conditions.



(a)



(b)

Figure 5: Searching using the Main Search Engine

3.1.2 Supplementary Search Engine: Search According to Acceptance Criteria

The acceptance criteria for recordings are entered in the search engine data boxes shown in Figure 6 (location 2 in Figure 2). As described below, acceptance criteria are specified by indicating the allowable range or restriction for the parameters listed in Table 1. Any recording satisfying these criteria in conjunction with the entries from the Main Search Engine will be listed on the Results table (location 4 in Figure 2). This feature is especially convenient to finetune the search results from the Main Search Engine. The "*Load Sample Values*" option will fill in the entry boxes with some example values.

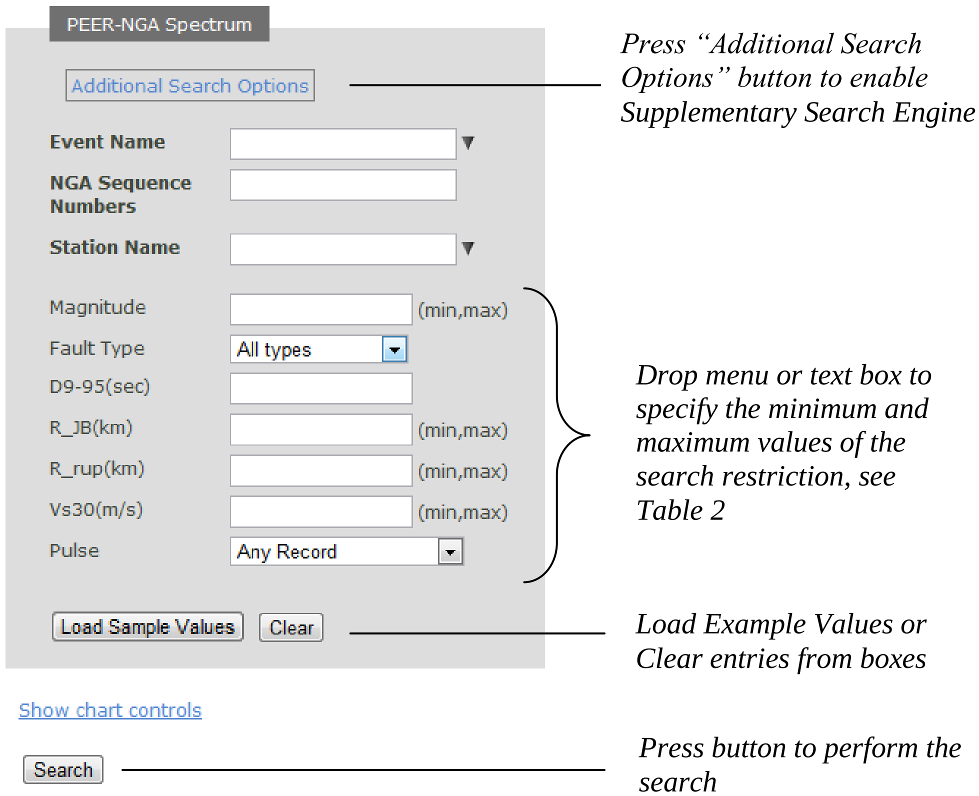
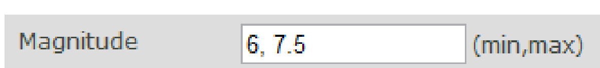


Figure 6: Supplementary Search Engine User Interface.

Data field input format

- The range of acceptable values for a recording parameter is entered into the data box. The acceptance range is specified by the minimum and the maximum values. The minimum and maximum values should be delimited by a **comma** or **space**. For example:



- An input box can be left **BLANK** if **no** search restriction is imposed on that data field. For example:

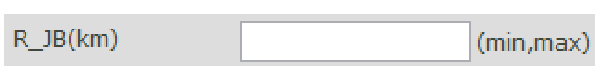


Table 1: Parameters for PGMD Search Engine

Data Field	Explanations
Magnitude	Restrict range of moment magnitude, input in the format of [min, max] or leave as blank for no restriction.
Fault Type	Types of fault mechanism. Options are: (1) All types of fault; (2) Strike Slip; (3) Normal or Normal Oblique; (4) Reverse or Reverse Oblique; (5) Combination of (2, 3); (6) Combination of (2,4); (7) Combination of (3,4).
D5-95(sec)	Restrict range of the significant duration of the records, input in the format of [min, max], or leave as blank for no restriction. The duration is defined as the time needed to build up between 5 and 95 percent of the total Arias intensity.
R_JB (km)	Restrict range of Joyner-Boore distance, input in the format of [min, max], or leave as blank for no restriction.
R_rup (km)	Restrict range of closest distance to rupture plane, input in the format of [min, max], or leave as blank for no restriction.
Vs30 (m/s)	Average shear wave velocity of top 30 meters of the site.
Pulse	Restrict the pulse characteristics of the searched record. Options are: (1) Any record; (2) Only pulse-like record; (3) No pulse-like record.

3.2 Perform the Search

3.2.1 Search for Records

Once the search restrictions are specified, press "*Search*" button to perform the search.

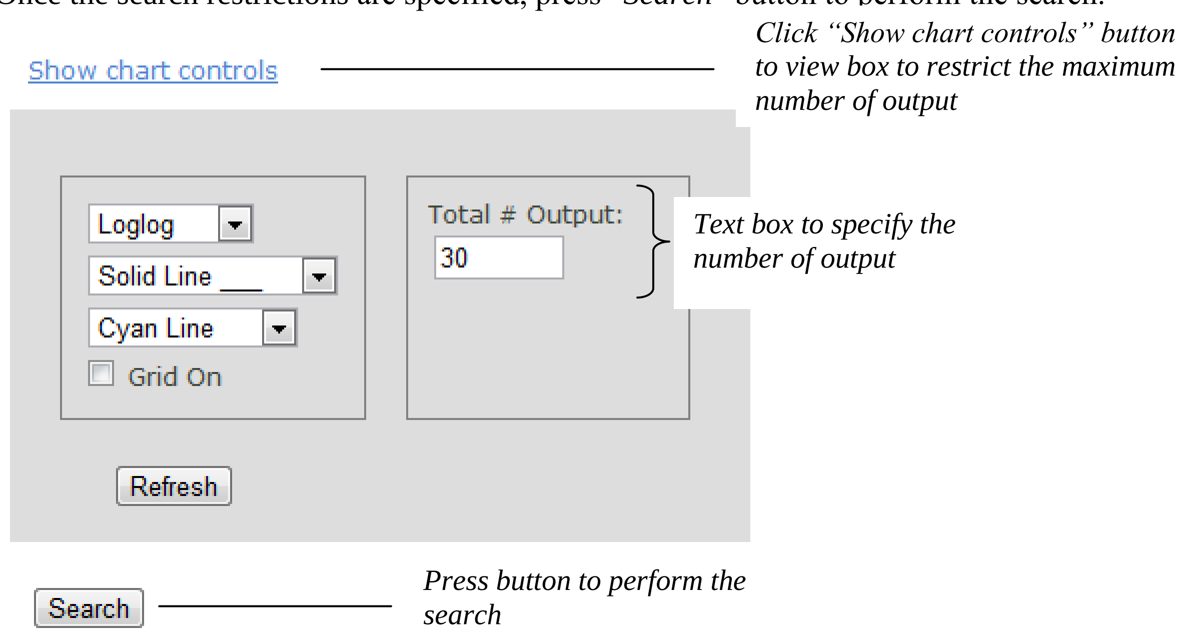
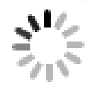


Figure 7: Restricting Output Number

A spinning wheel will appear and the data is processed according to the specified search restrictions, and specified number of records for output.



The best 30 (specified in *Total # Output* box) records will be displayed for inspection. If the total number of records that satisfy the acceptance criteria is less than the value of *Total # Output* specified by the user, the value of *Total # Output* is automatically reset to the maximum number of acceptable recordings in the database. **PGMD restricts the display of outputs up to 50 records** to avoid abuse of the program.

The spectra for all 30 output recordings will be displayed in the spectrum plot window, see Figure 8 for an example.

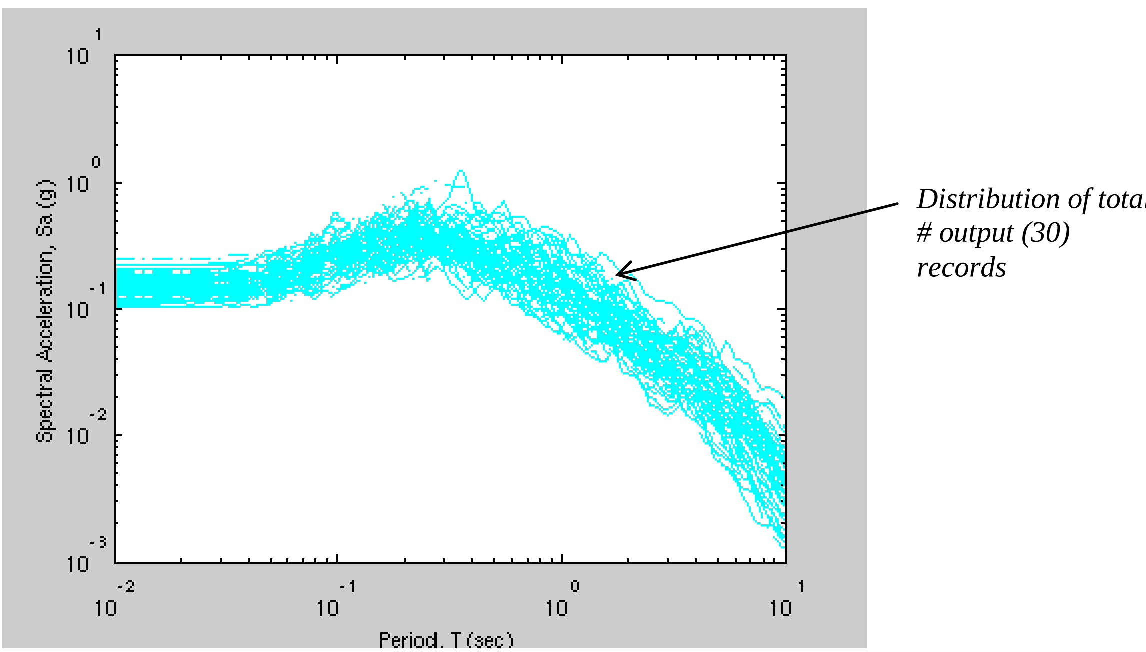


Figure 8: Example of Spectral Plot for the Unscaled Section

3.2.2 List the Search Result

PGMD lists the search results in the *Results window* for the total number of output records specified by users.

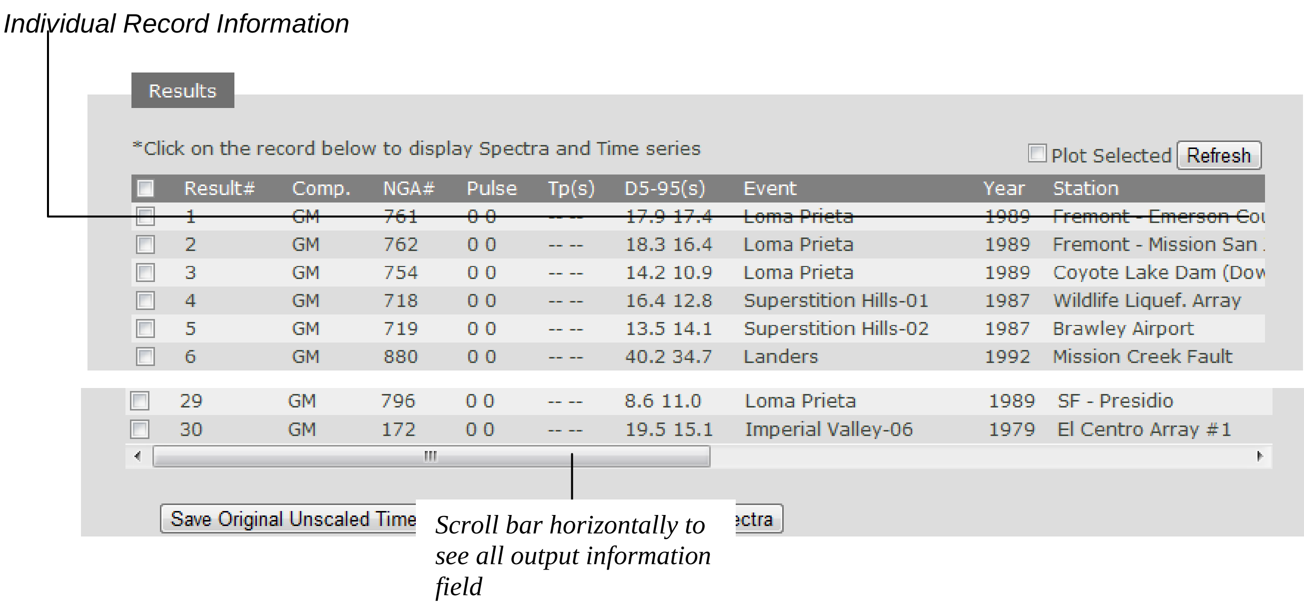


Figure 9: Output List Window

The listed information for each record is tabulated in Table 2.

Table 2. Listed Record Information of PGMD Search Result

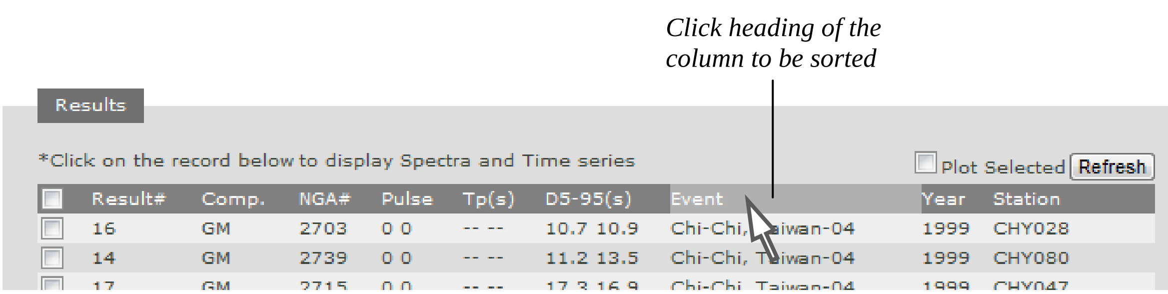
Result#	Number the records in ascending order.
Comp.	Component indicator: GM: Record of both FN and FP directions; use geometric mean of two components.
NGA#	NGA number. A unique number assigned to each NGA record for identification purposes.
Pulse	Pulse Indicator: binary code to indicate if the unscaled record has velocity pulse. 0 for non-pulse-like record 1 for pulse-like record If the search is for two components in pair, the pulse indicator is shown for both components. The first binary is for fault normal record, and the second binary is for fault parallel record.
Tp (sec)	The period of the velocity pulse. No number is assigned for a non-pulse record. If the search is for two components in pair, pulse periods (if any) for both FN and FP components are given in order.
D5-95 (sec)	Significant duration, the time needed to build up between 5 and 95 percent of the total Arias intensity. If the search is for two components in pair, durations for both FN and FP components are given.

Event	Name of the earthquake event
Year	Year of earthquake
Station	The unique name of strong-motion station
Mag.	Moment magnitude of earthquake
Mechanism	Type of Fault Mechanism. Available mechanisms are: Strike-Slip, Normal, Normal-Oblique, Reverse, Reverse-Oblique.
Rjb (km)	Joyner-Boore distance to rupture plane
Rrup (km)	Closest distance to rupture plane
V_{S30} (m/s)	Average shear velocity of top 30 m
Lowest Usable Freq. (Hz)	The recommended lowest usable frequency for the record. (see Footnote (1) below)

3.2.3 Sort the Search Result

The *Results* table is populated according to the inherited structure of the dataset that is by progressive NGA number. The recommendation for the user is to be as specific as possible when inputting the search parameters. If for example the user only specifies a magnitude range of 6, 7 then the records listed on the *Results* table will only display a few events. This is because of the limitation on the amount of results that can be displayed on the *Results* table

The *Results* table can be sorted by any column. Place your cursor on the heading of the column to be sorted (ex: Event) until it changes color to a light gray. Then, click at the heading and the results are sorted according to that column.



Footnote (1): The recommended lowest usable frequency is related to filtering of a record by the record processing organization to remove low-frequency (long-period) noise. Filtering results in suppression of ground motion amplitudes and energy at frequencies lower than the lowest usable frequency such that the motion is not representative of the real ground motion at those frequencies. It is a user's choice on whether to select or reject a record on the basis of the lowest usable frequency. Because of the suppression of ground motion at frequencies lower than the lowest usable frequency, it is recommended that selected records have lowest usable frequencies equal to or lower than the lowest frequency of interest.

3.3 SELECTION AND EVALUATION OF RECORDS

3.3.1 Plotting Response Spectrum of an Individual Record

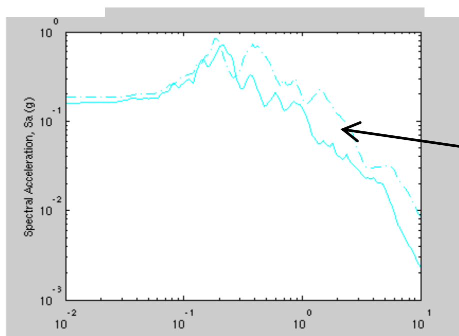
Once the user clicks the Search button, the spectral acceleration plots for all the records listed on the *Results* table are shown. The user can display the spectral acceleration plot for an individual record by simply checking the box corresponding to the record and then checking the box *Plot Selected*. The following example shows a particular record (Result# 3) checked and the two components of the record (FN and FP) being plotted.

*Click on the record below to display Spectra and Time series — ☑ Plot Selected [Refresh]

☐	Result#	Comp.	NGA#	Pulse	Tp(s)	D5-95(s)	Event	Year	Station
☐	1	GM	761	0 0	-- --	17.9 17.4	Loma Prieta	1989	Fremont - Emerson Cou
☐	2	GM	762	0 0	-- --	18.3 16.4	Loma Prieta	1989	Fremont - Mission San .
☑	3	GM	754	0 0	-- --	14.2 10.9	Loma Prieta	1989	Coyote Lake Dam (Dow
☐	4	GM	718	0 0	-- --	16.4 12.8	Superstition Hills-01	1987	Wildlife Liquef. Array

Check an individual record

Check to only plot results that have been selected (Result# 3).



Spectral Acceleration plots of the FN and FP components of record Result# 3

Figure 10: Plotting the Response Spectrum of an Individual Record

3.3.2 Plotting Response Spectrum of Multiple Record

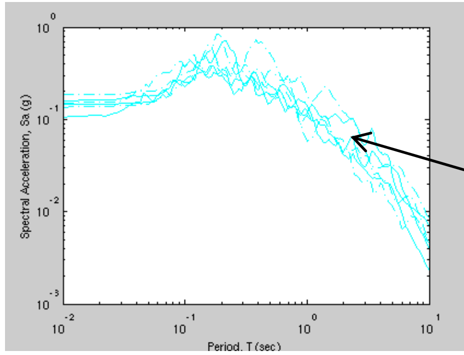
The user can display the spectral acceleration plot for multiple records, by checking the box corresponding to all the records to be displayed and then clicking the *Plot Selected* box. If the *Plot Selected* box was previously checked, then simply press the *Refresh* button as shown on the following example.

*Click on the record below to display Spectra and Time series — ☑ Plot Selected [Refresh]

☐	Result#	Comp.	NGA#	Pulse	Tp(s)	D5-95(s)	Event	Year	Station
☐	1	GM	761	0 0	-- --	17.9 17.4	Loma Prieta	1989	Fremont - Emerson Cou
☑	2	GM	762	0 0	-- --	18.3 16.4	Loma Prieta	1989	Fremont - Mission San .
☑	3	GM	754	0 0	-- --	14.2 10.9	Loma Prieta	1989	Coyote Lake Dam (Dow
☑	4	GM	718	0 0	-- --	16.4 12.8	Superstition Hills-01	1987	Wildlife Liquef. Array
☐	5	GM	719	0 0	-- --	13.5 14.1	Superstition Hills-02	1987	Brawley Airport

Check multiple records

Check to only plot results that have been selected (Result# 2, 3, 4). If the Plot Selected box has been previously checked then press the Refresh button.



Spectral Acceleration plots of the FN and FP components of record Result# 2, 3, 4

Figure 11: Plotting the Response Spectrum of Multiple Records

All the results from the table can be plotted by checking the box on the heading of the *Results* table and then checking the *Plot Selected* box, or by pressing Refresh, if the *Plot Selected* box was previously checked.

Check this box to select all the records

☑	Result#	Comp.	NGA#
☑	1	GM	761
☑	2	GM	762
☑	3	GM	754

3.3.3 Display Location of Selected Earthquake Recordings on Goggle Map

When the user performs a search, a balloon showing the location of all the record listed on the *Results* table is placed on the Google map window. Besides showing the location where the earthquake occurred, each balloon, when clicked, displays the NGA Seq Number, Event Name, Station Name, Latitude and Longitude corresponding to each individual record as shown in Figure 12.

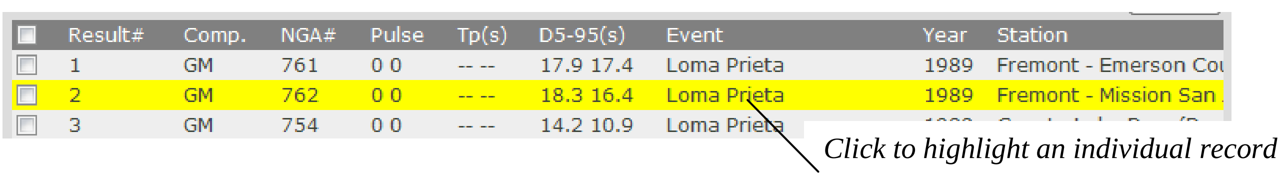
Figure 12: Location where Earthquake was Recorded

If the user checks any individual record on the *Results* table, then only the records that were checked are displayed on the Google map window.

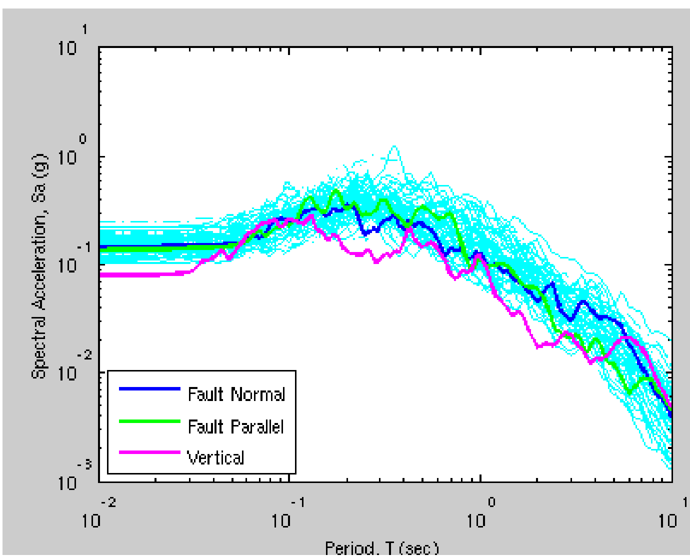
3.3.4 Highlight an Individual Record

The response spectrum and acceleration, velocity, and displacement time series for unscaled individual records can be easily visualized in PGMD, providing users the capacity to inspect the records in greater detail. The user can simply click on the record line in the Results window, and the selected record line will be highlighted in yellow. The following example shows

highlight the *unscaled* fault-normal (in blue color), fault-parallel (in green color) and vertical (in magenta color) response spectra for record NGA#762.



(a) Highlight an individual record on the output List



(b) Plot of fault-normal, fault-parallel and vertical spectrum of highlighted record

Figure 13: Highlight and Plot of an Individual Record

3.3.5 Highlight Time Series of an Individual Record

Once an individual record is highlighted, the **unscaled** acceleration/velocity/displacement time series is automatically plotted in *Time Series Plot Window*. The user can select the drop menu to plot acceleration or velocity or displacement time series. Figure 14 shows the *unscaled* time series for a highlighted record (NGA#762 in this case).

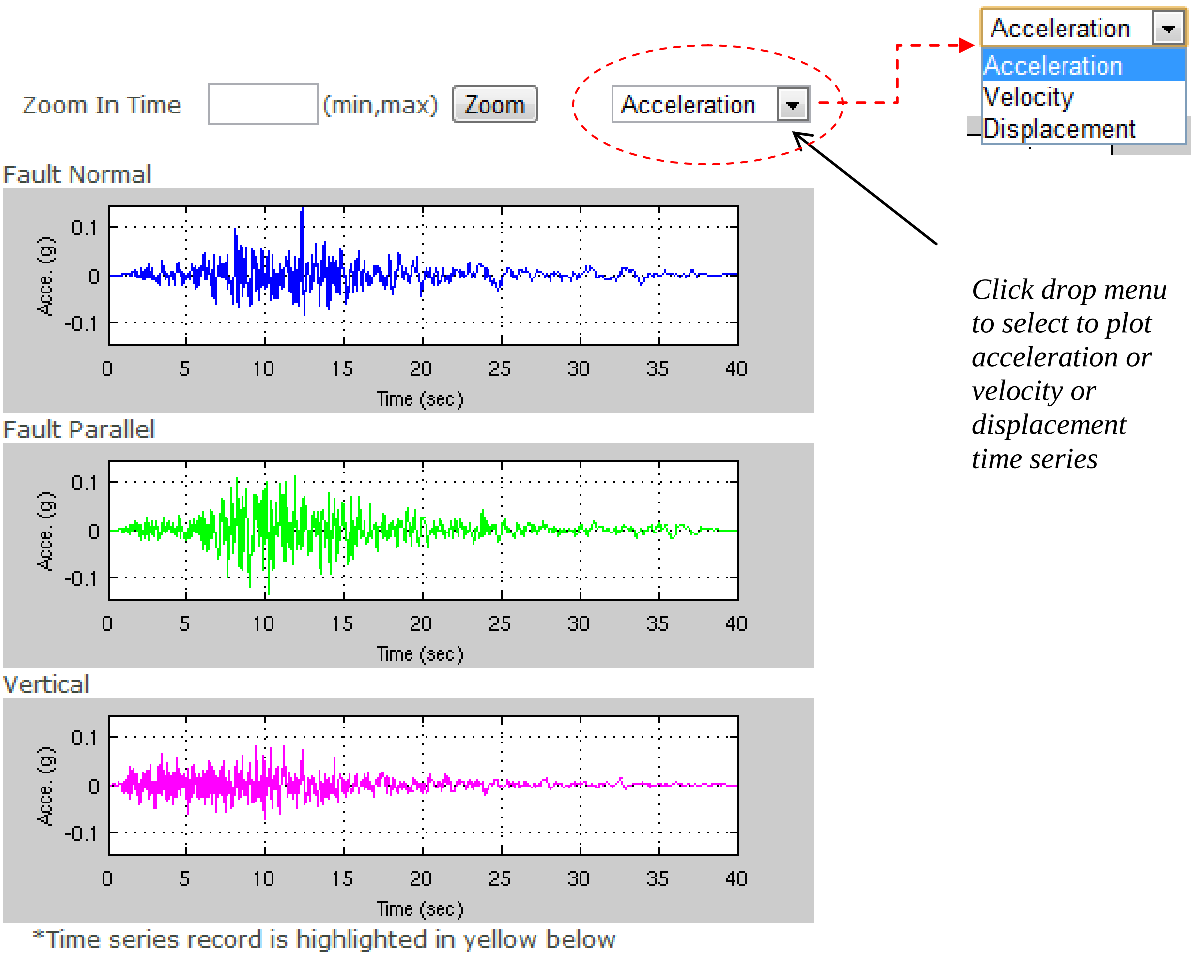
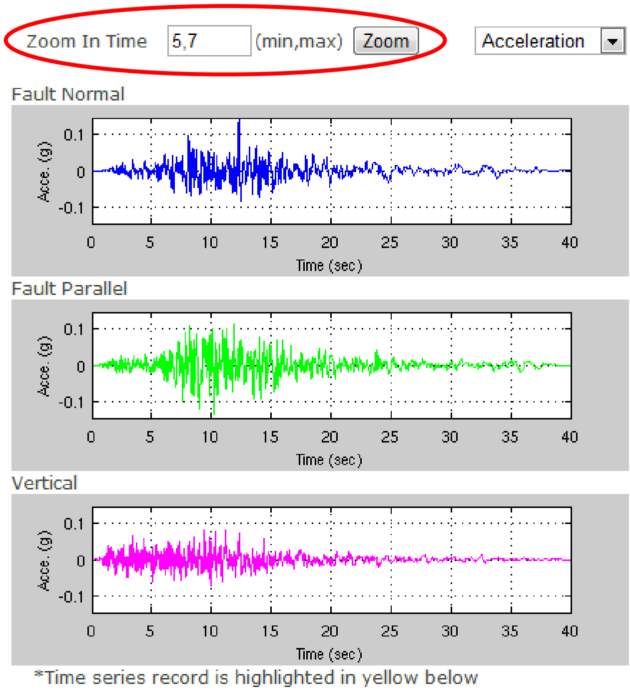


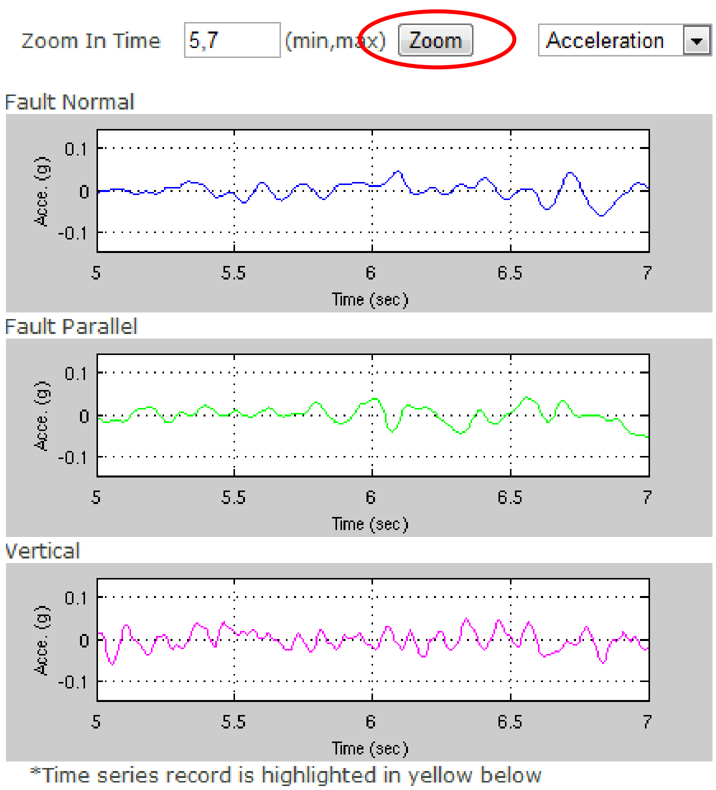
Figure 14: Plot of the Scaled Acceleration/Velocity/Time Series of an Individual Record in Fault Normal, Fault Parallel and Vertical Directions

3.3.6 Zoom In Time Function for Examining the Time Series of an Individual Record

The "Zoom In Time" function is provided to help the user inspect the details of the time series plot. The function can be activated by filling in the "Zoom In Time" box in the form of "min, max". The example in Figure 15 shows the effect of a zoom in between 5-7 seconds on the acceleration time series. To zoom out, one can input blank in the input box and click "Zoom".



(a) Key in the time range to "zoom in" in the format of [min, max]. The acceleration time series zooms in between 5-7 seconds in this example.



(b) Click the "Zoom" button

Figure 15: Zoom In Time Series Plot

3.4 CHART CONTROL

3.4.1 Chart Control Panel

The chart control panel provides the functionality to manipulate the spectrum plot. The panel becomes visible after clicking "Show chart controls". Basic functions of the control panel are summarized in Figure 16.

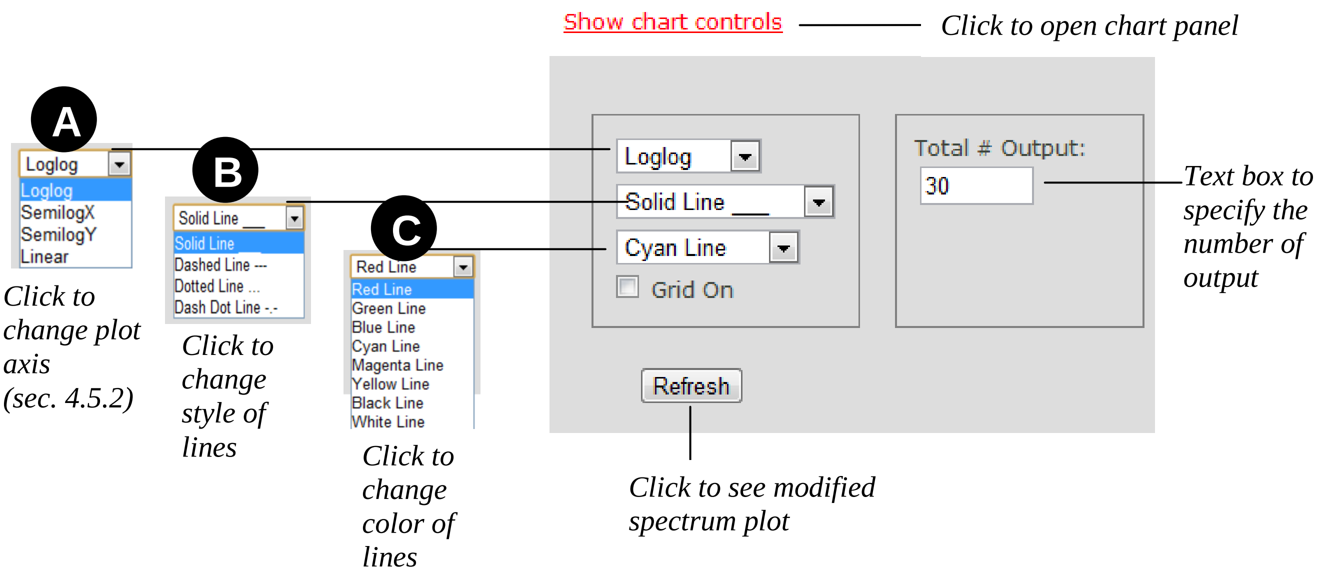
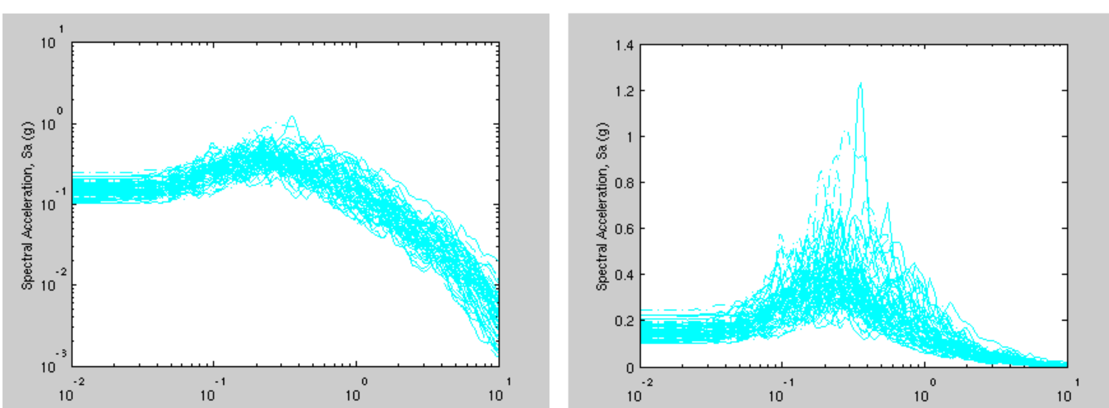


Figure 16: Chart Control Panel

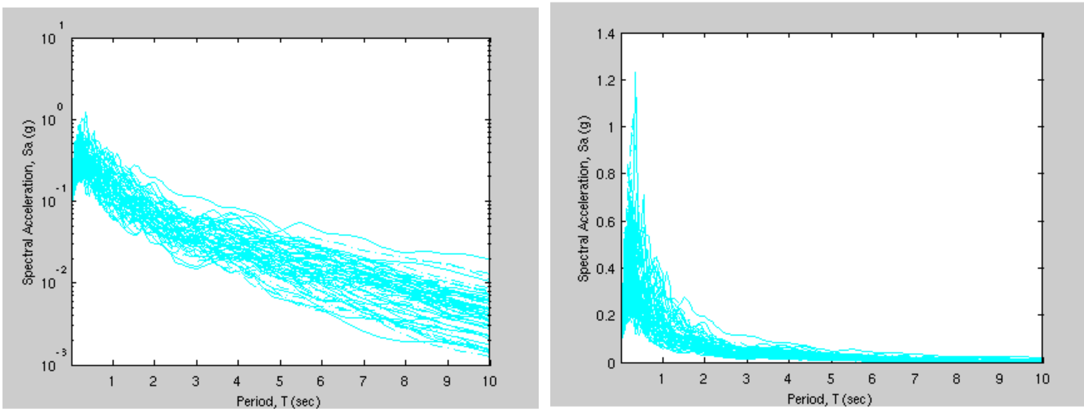
3.4.2 Change Plot Axes

The axes of the spectrum plot can be changed from logarithmic scale to linear scale by selecting options in the drop menu. The following plots in Figure 17 illustrate four options available to change the axes of a same plot.



(a) log-log axes

(b) semilogx axes



(c) semilogy axes (d) linear axes

Figure 17: Example of Four Options to Change Plot Axes

3.5 SAVE PGMD SEARCH RESULT

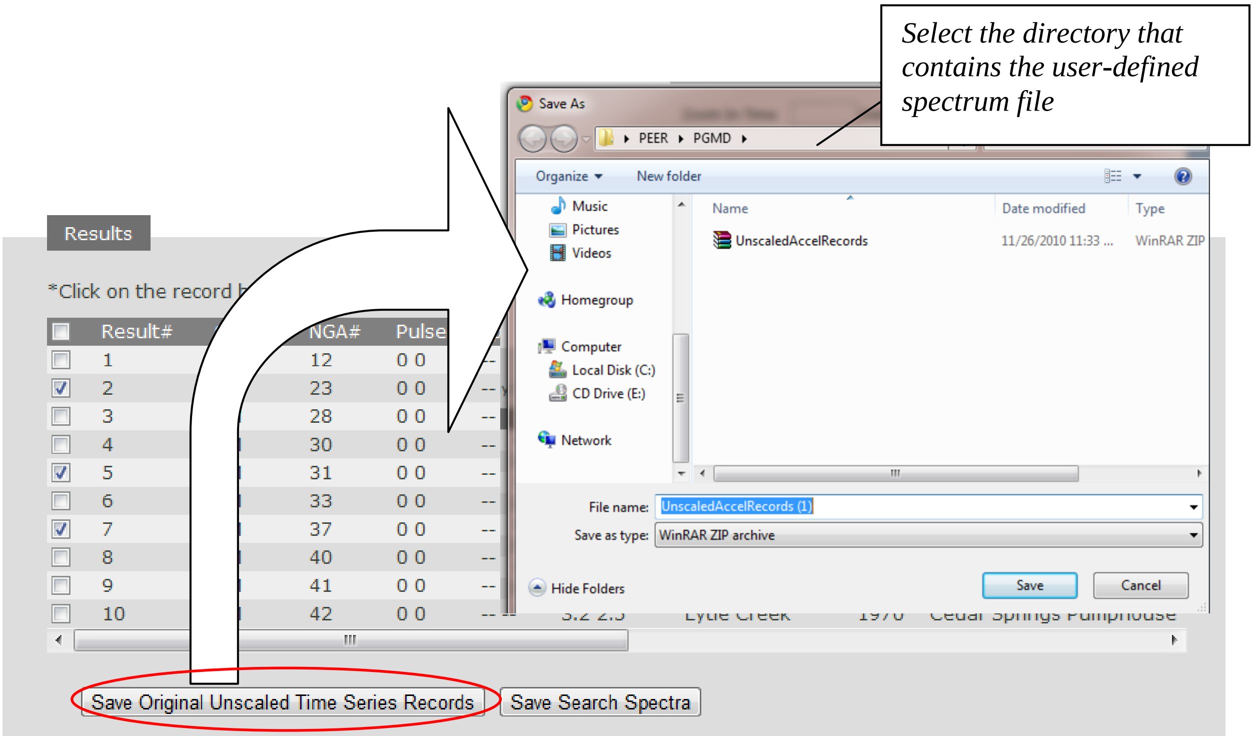
3.5.1 Save Acceleration Time Series Files

PGMD allows users to save the selected acceleration time series file. **Please note that the saved time series file contains <u>unscaled</u> original data as in the PEER NGA database**. The steps are illustrated in Figure 18.

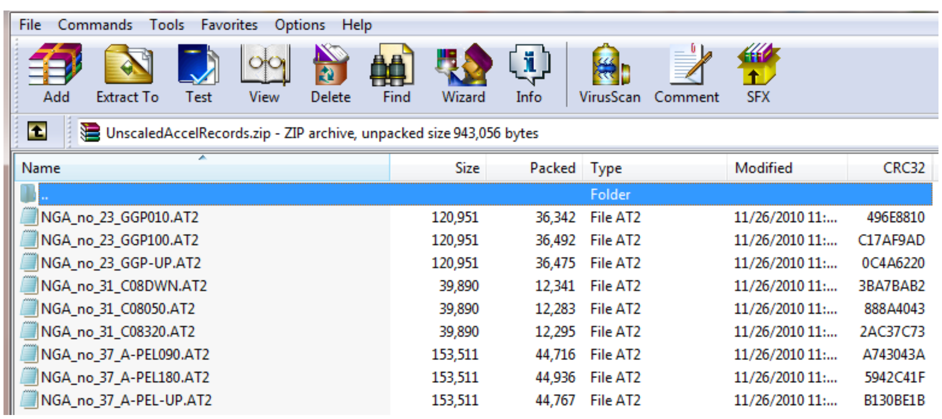
Step (1): user checks the record to be saved (in this example, records 2, 5 and 7). The horizontal and vertical time series files will be saved.

Step (2): click “Save Original Unscaled Time Series Records” button. A pop-up window allows the user to specify the save directory and file name of the compressed time series files.

Step (3): extract the time series file. The file name assigned uses the convention of “NGAnumber_filename” to distinguish each record as it has a unique NGA number.



(a) Step (1) and (2)



(b) Step (3)

Figure 18: Save Acceleration Time Series Files

3.5.2 PGMD Search Report

The PGMD search criteria and summary of the selected records can be exported by clicking "Save Search Spectra" button (cf. Figure 18). The horizontal components and the vertical component information will be exported together. A pop-up window allows the user to specify the file name and file type ("csv' or 'txt' format). "cvs" (Comma Separated Variables) file format is preferred since it can be opened using Microsoft Excel, or any text editor.

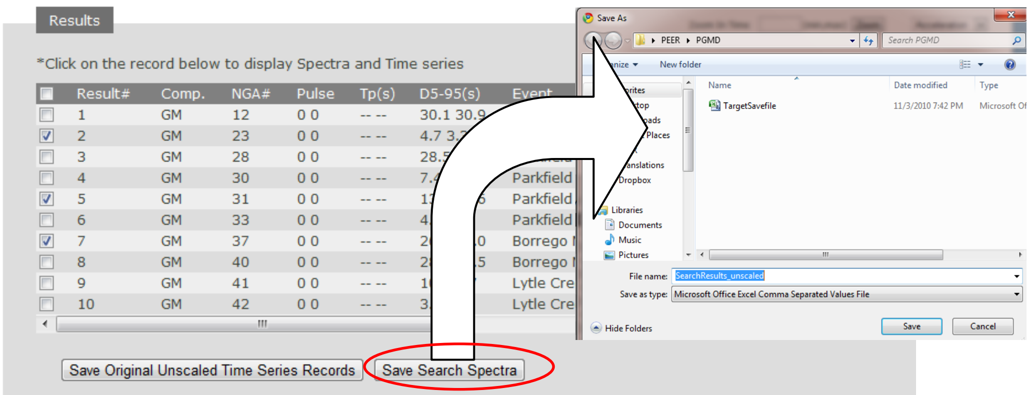


Figure 19: Save PGMD Search Result

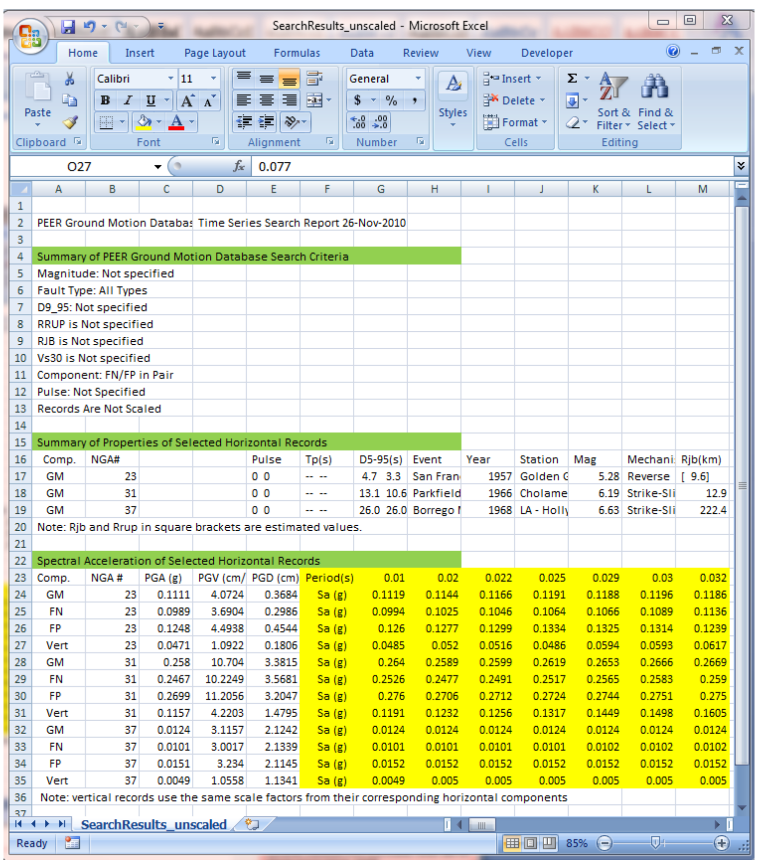


Figure 20: An Example of PGMD Search Report

Figure 20 illustrates an example of the PGMD search report (named as SearchResults_unscaled.csv in this case) opened by Microsoft Excel. The search report features the following data blocks:

(1) ***Summary of PGMD search criteria.*** All user-defined search criteria are listed in this data field, including the magnitude range, fault type, specified D9-95 range, specified R_{rup} and R_{jb} ranges, specified V_{S30} range, component specification, pulse characteristics, unscaled records.

(2) ***Summary of Properties of Selected Horizontal and Vertical Records.*** The same information in the PGMD output list window is reported only for selected records (the ones that had their box checked). The reported properties of each selected record are: Component Indicator, NGA number, Pulse Indicator, Pulse Periods, D5-95 duration, Event Name, Year, Station Name, Magnitude, Fault Mechanism, R_{JB}, R_{Rup}, V_{S30}, recommended lowest usable frequency, and the acceleration record file names. Please note that if R_{JB} or R_{Rup} is in a squared bracket, it indicates that the value is absent in NGA Flatfile. The reported value was estimated by Chiou and Youngs (2008b).

(3) ***Unscaled Spectral Acceleration of Selected Horizontal Records***. For each selected record listed in data field (2), their component indicator, NGA number, scale factor, *unscaled* PGA, PGV, PGD values and *unscaled* spectra acceleration values are reported in this data field. The unscaled spectra acceleration values are reported for the following periods (in seconds):

0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.036	0.04
0.042	0.044	0.045	0.046	0.048	0.05	0.055	0.06	0.065	0.067
0.07	0.075	0.08	0.085	0.09	0.095	0.1	0.11	0.12	0.13
0.133	0.14	0.15	0.16	0.17	0.18	0.19	0.2	0.22	0.24
0.25	0.26	0.28	0.29	0.3	0.32	0.34	0.35	0.36	0.38
0.4	0.42	0.44	0.45	0.46	0.48	0.5	0.55	0.6	0.65
0.667	0.7	0.75	0.8	0.85	0.9	0.95	1	1.1	1.2
1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2.5	2.6	2.8	3	3.2	3.4	3.5	3.6	3.8	4
4.2	4.4	4.6	4.8	5	5.5	6	6.5	7	7.5
8	8.5	9	9.5	10					

3.5.3 Save the Plot

Both spectrum and time series plots can be saved to the disk as figure files. The steps are illustrated in Figure 21. Step (1): Right click the mouse on the plot area, Step (2) Click "Save Image As" Step (3): Select the proper directory, and enter the name of the graphic file to save.

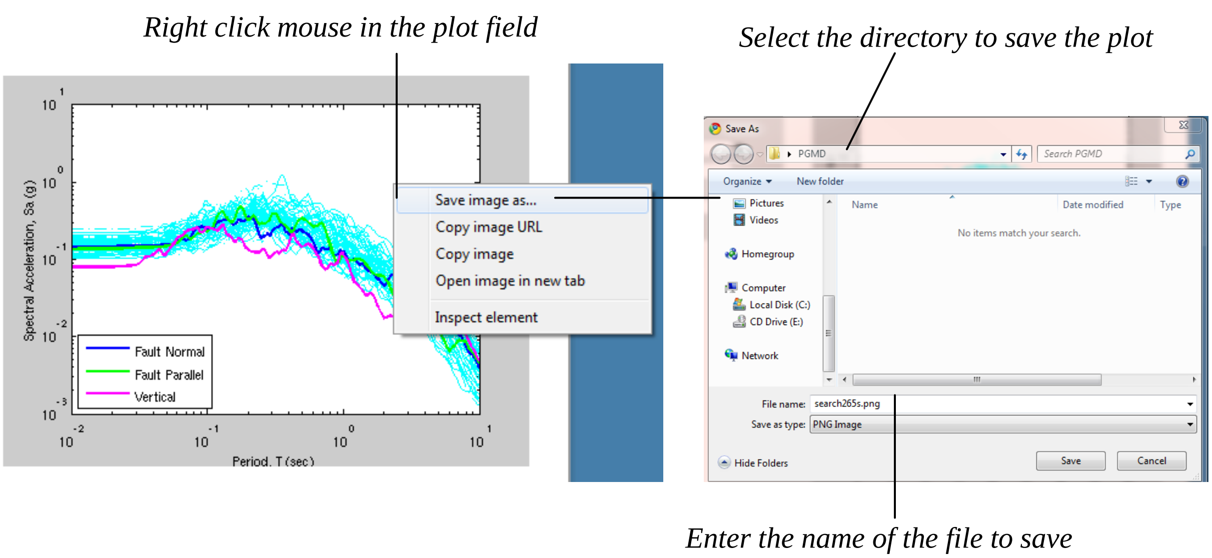


Figure 21: Steps to Save the Plot

4. CREATE TARGET SPECTRUM

The TARGET SPECTRUM window is shown in Figure 22. The window contains the following main parts: (1) Select Spectrum Model; (2) Specifications of Selected Model; (3) Explanation of notations; (4) Plot Control panel; (5) Plot Control; (6) Create Target Spectrum button.

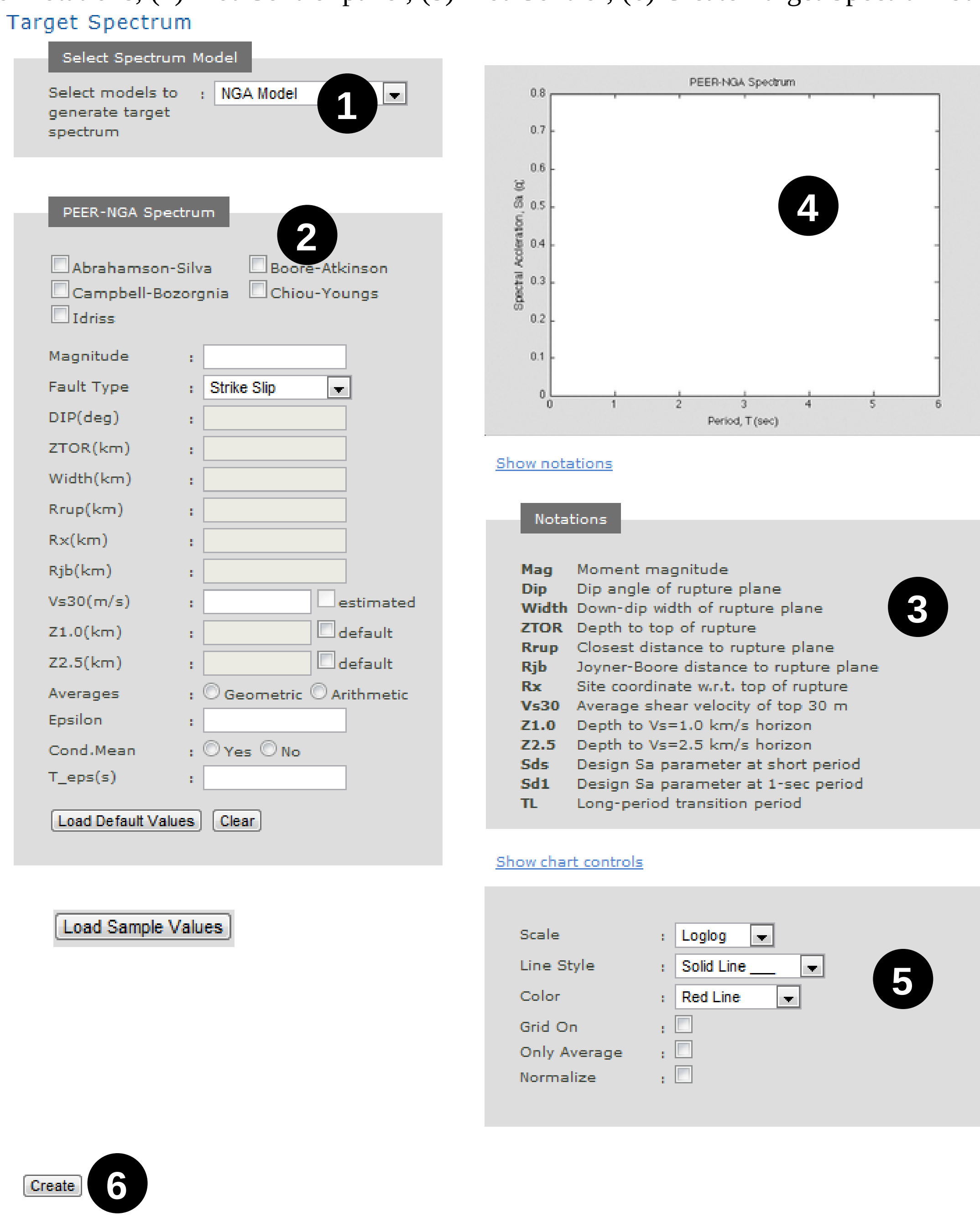


Figure 22: Create Target Spectrum Window

4.1 SELECT SPECTRUM MODEL

The first step is to select the spectrum model to generate the target spectrum. Three options are available by mouse-clicking the drop menu at location (1) in Figure 22:

(1) PEER-NGA Model;
(2) User defined spectrum;
(3) ASCE/SEI Standard 7-05 code specified spectrum.

Once a spectrum model is selected, the corresponding panel for parameter input will be displayed at location (2) in Figure 22.

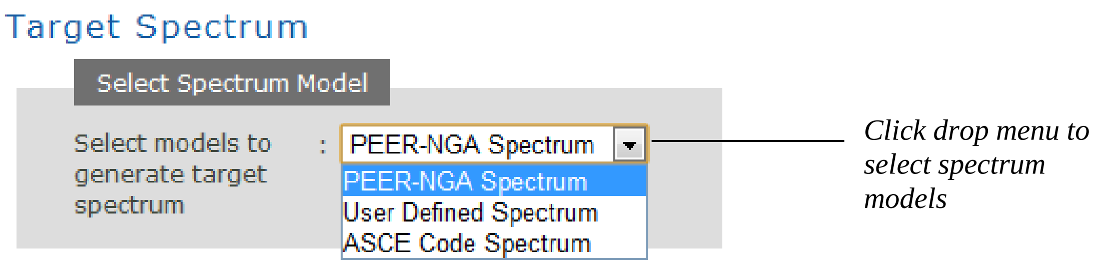


Figure 23: Selection of Spectrum Model

4.1.1 PEER-NGA Model

The "PEER-NGA Spectrum" model creates a target response spectrum using the PEER-NGA ground motion prediction equations (GMPEs) published in the February, 2008 issue of *Earthquake Spectra*. Five NGA empirical models are employed in PGMD: Abrahamson-Silva (A&S, 2008), Boore-Atkinson (B&A, 2008), Campbell- Bozorgnia (C&B, 2008), Chiou-Youngs (C&Y, 2008a), and Idriss (2008). The spectrum is defined for a specific scenario earthquake defined in terms of magnitude, distance, style of faulting, and site conditions as specified in the PEER-NGA ground motion models. This option is selected by clicking the drop menu and selecting "PEER-NGA spectrum" option. The panel shown at location (2) in Figure 22 allows the user to input the necessary parameters to generate a PEER-NGA spectrum. An expanded view of this input panel is shown in Figure 24. The required input parameters are described below.

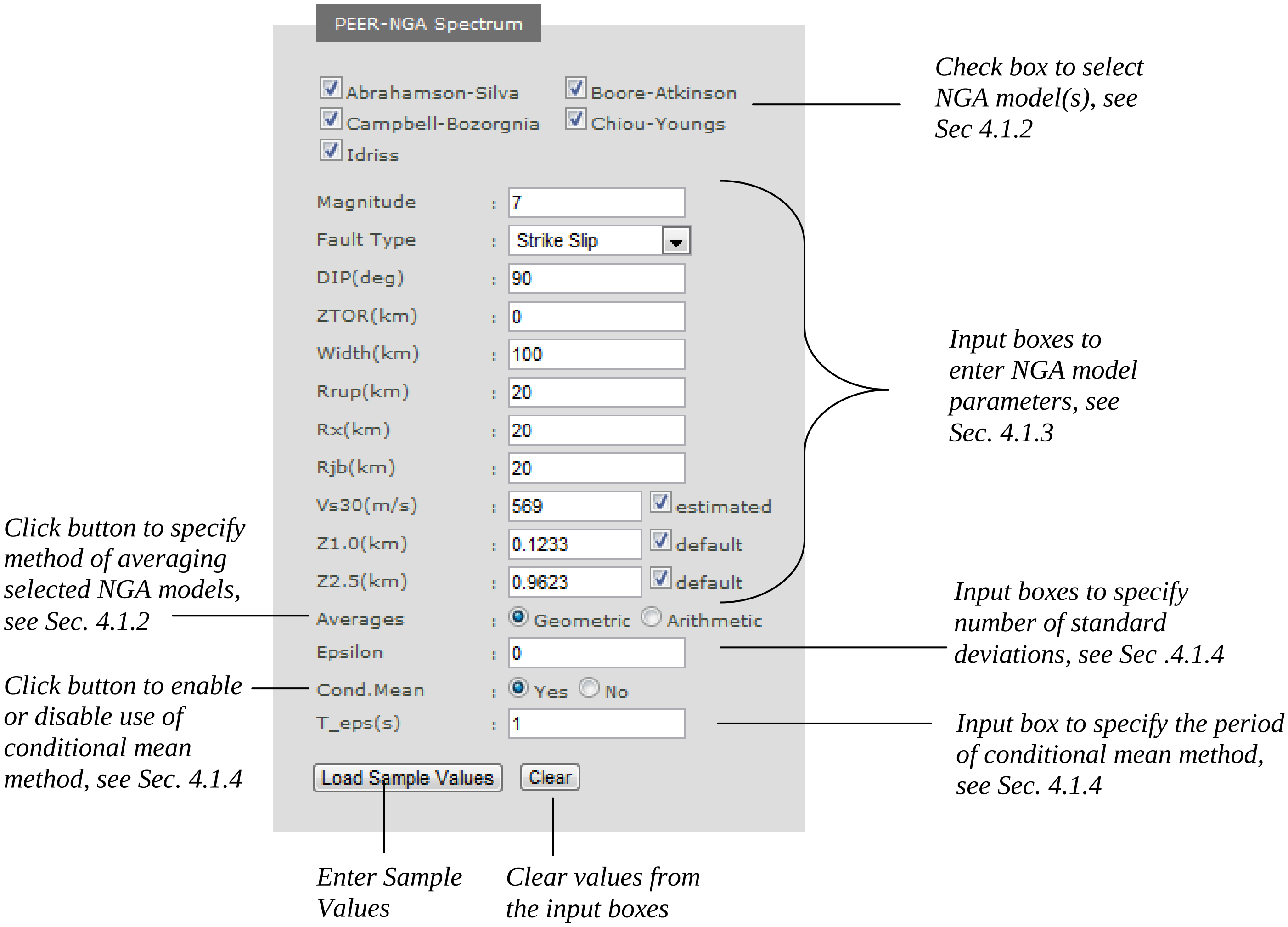


Figure 24: Input Panel for Creating a PEER-NGA Spectrum

4.1.2 Select PEER-NGA Ground Motion Prediction Models

Use check boxes to select the PEER-NGA ground motion prediction models to be used. The user has the option to use any single, or any combination, of these NGA models, except that the Idriss (2008) model is not applicable to cases where V_{S30} is less than 450m/s, or fault type is normal or normal oblique faulting. In such cases, PGMD will automatically display a warning "Idriss is NOT applicable to cases where Vx30< 450m/s or Normal Faulting". If the Idriss (2008) model is selected by the user and is applicable for the conditions specified by the user (i.e. Vs30>=450m/s and strike slip faulting or reverse or reverse oblique faulting), then the Idriss model will be used.

If more than one model is selected, the user can further specify the resulting average target spectrum to be the arithmetic or the geometric mean of the spectra produced by the selected models.

The arithmetic mean of *n* spectra is defined as follows

$$SA(T) = \frac{1}{n}\left(\sum_{i=1}^{n} SA_i(T)\right)$$

where $SA_i(T)$ is the spectrum produced by model *i*; The geometric mean of spectra can be viewed as the arithmetic mean of the logarithm-transformed values (i.e., the arithmetic mean of the logarithms), and then using exponentiation to return the logarithm values to the natural scale actual values. The geometric mean of *n* spectra is defined as follows

$$\ln SA(T) = \frac{1}{n}\left(\sum_{i=1}^{n} \ln SA_i(T)\right) \quad \text{or} \quad SA(T) = \exp\left(\frac{1}{n}\sum_{i=1}^{n} \ln SA_i(T)\right)$$

4.1.3 Ground Motion Prediction Model Input Parameters

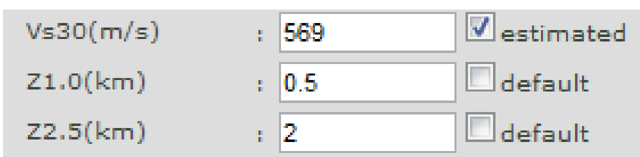
Depending on the PEER-NGA ground motion prediction models selected, the user must enter up to twelve parameters in the data input boxes to construct the response spectrum. Parameters required by each ground motion model are listed in Table 3. PGMD will only enable the input boxes for the necessary parameters according to the model selection specified by the user.

Table 3: Parameters for PEER-NGA Ground Motion Prediction Models

	A&S	**B&A**	**C&B**	**C&Y**	**Idriss**	**Explanations**
Magnitude	✓	✓	✓	✓	✓	Moment magnitude of the earthquake
Fault Type	✓	✓	✓	✓	✓	Types of fault mechanism. Options are: (1) Strike Slip; (2) Normal or Normal Oblique; (3) Reverse or Reverse Oblique
Dip (deg)	✓		✓	✓		Dip angle of rupture plane
Width (km)	✓		✓	✓		Down-dip width of rupture plane
Z_{TOR} (km)	✓		✓	✓		Depth to top of rupture plane
R_{JB} (km)	✓	✓	✓	✓		Joyner-Boore distance to rupture plane
R_{Rup} (km)	✓		✓	✓	✓	Closest distance to rupture plane
R_X (km)	✓			✓		Site coordinate w.r.t. top of rupture
V_{S30} (m/s)	✓	✓	✓	✓	✓	Average shear wave velocity of top 30 m
estimated	✓			✓		Specifying V_{S30} is estimated or measured
$Z_{1.0}$ (km)	✓			✓		Depth to V_S=1.0 km/s horizon
$Z_{2.5}$ (km)			✓			Depth to V_S=2.5 km/s horizon
Epsilon	✓	✓	✓	✓	✓	Number of standard deviations away from the median spectrum
T_eps	✓	✓	✓	✓	✓	The period upon which conditional mean spectrum is conditioned

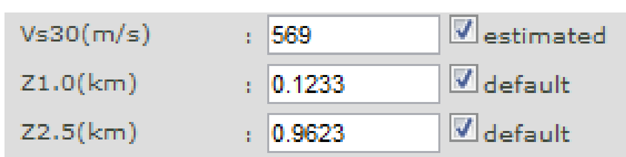
Remarks:

1. Magnitude, Fault Type, Dip, Width and Z_{TOR} are parameters that define the seismic source. R_{JB}, R_{Rup}, R_X define different types of distance measures from the site to the fault rupture. V_{S30}, $Z_{1.0}$ and $Z_{2.5}$ are used to describe the site condition.
2. Definition of R_{JB}, R_{Rup}, and R_X are shown in Figure 25 for strike-slip faulting and for reverse or normal faulting with the site on the hanging-wall and the foot-wall side. Rrup is the closest distance to the rupture plane; R_{JB} is Joyner-Boore distance defined as the closest horizontal distance to the trace of the rupture that is vertically projected to the ground surface. R_{Rup} and R_{JB} are always non-negative numbers. Please note that R_X is the horizontal coordinate of the site with respect to the top of the rupture. For a reverse or normal fault, if the site is on the hanging wall side, R_X is a positive value; if the site is on the footwall side, R_X is a negative value. Therefore, PGMD does not provide a separate hanging wall flag, instead, the sign of R_X is used to indicate a hanging wall condition for a reverse or normal fault. For a strike-slip fault, it does not matter whether R_X is positive or negative.
3. Parameters $Z_{1.0}$ and $Z_{2.5}$ specify the depths at which the shear wave velocity reaches 1.0 km/s and 2.5km/s at the site, respectively. A user can specify the values of $Z_{1.0}$ and $Z_{2.5}$ directly as shown in the following check boxes. The "default" checkboxes will be automatically unchecked once a user keys in numbers.



user-specified $Z_{1.0}$ and $Z_{2.5}$ values

4. Default values of $Z_{1.0}$ and $Z_{2.5}$ can also be used by checking the "default" checkboxes. Empirical relationships are used to estimate $Z_{1.0}$ value based on V_{S30}, and the default values are automatically displayed in the text boxes thereafter.



use default values of $Z_{1.0}$ and $Z_{2.5}$

A&S model uses the following empirical equations to estimate $Z_{1.0}$, where the unit of $Z_{1.0}$ is in km, and V_{S30} is in m/s.

$$Z_{1.0} = \begin{cases} \exp(6.745)/1000 & \textit{if} \quad V_{S30} < 180\ m/s \\ \exp(5.394 - 4.48 * 1n(V_{S30}/500))/1000 & \textit{if} \quad V_{S30} > 500\ m/s \\ \exp(6.745 - 1.35 * 1n(V_{S30}/180))/1000 & \textit{if} \quad 500\ m/s \geq V_{S30} \geq 180\ m/s \end{cases}$$

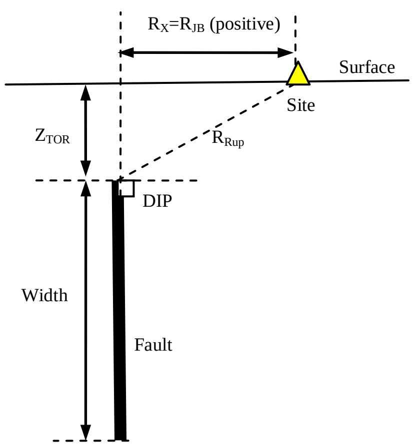
C&Y model uses the following relationship to estimate $Z_{1.0}$,
$Z_{1.0} = \exp(28.5 - 3.82/8 * 1n(V_{S30}^8 + 378.8^8))/1000$

Please note the difference of empirical correlations used by A&S and C&Y, where the estimate of $Z_{1.0}$ from C&Y is always smaller than that from A&S. If both A&S and C&Y models are specified in PGMD, the above relation is used accordingly for each model. For simplicity, PGMD only displays $Z_{1.0}$ values estimated by A&S model, but different $Z_{1.0}$ values are used as the default for C&Y model. Parameter $Z_{2.5}$ is used only by C&B model. Default value of $Z_{2.5}$ is determined based on the value of $Z_{1.0}$. If $Z_{1.0}$ is specified by the user, the following relation is used to estimate $Z_{2.5}$ based on $Z_{1.0}$ (both in units of km)

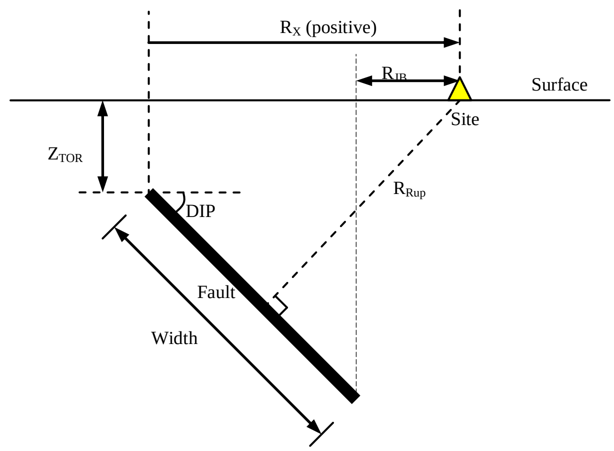
$$Z_{2.5} = 0.519 + 3.595 * Z_{1.0}$$

Otherwise, PGMD estimates $Z_{1.0}$ first using relationship proposed by A&S, and then $Z_{2.5}$ is estimated using above equation.

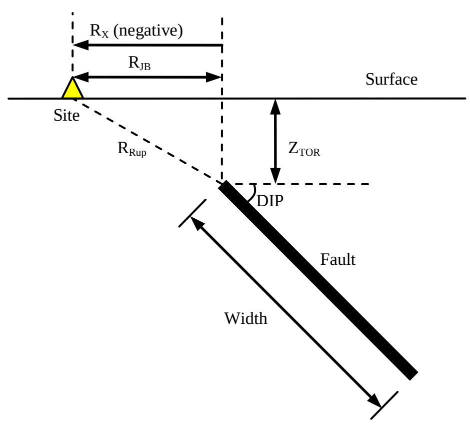
5. It is the user's responsibility to ensure the input parameters are correct. The PGMD does NOT check the consistency of the input data.



(a) Strike slip faulting



(b) Reverse or normal faulting, hanging-wall site



(c) Reverse or normal faulting, foot-wall site

Figure 25: Definition of Fault Geometry and Distance Measures

4.1.4 Number of Standard Deviations and Conditional Mean Spectrum

The PEER-NGA ground motion prediction models provide relationships for the median ground motion amplitude (mean value in log space) and for the aleatory variability about the median value. The aleatory variability is defined as the standard deviation of the natural log of the spectral acceleration. **Parameter epsilon is used to define the number of standard deviations away from the median represented by a particular ground motion level.** For example, the 84^{th}-percentile spectrum is a spectrum where the ground motion levels are one standard deviation above the median at all spectral periods (epsilon = 1.0).

The user has two options for incorporating aleatory variability in the target spectrum developed from the PEER-NGA models. The first option is to use a constant value of epsilon at all spectral periods (e.g. epsilon=1.0 for an 84^{th}-percentile spectrum). The second option is to develop a conditional mean spectrum (Baker and Cornell, 2006) in which the user specifies the value of epsilon at a specific spectral period and the correlation model developed by Baker and Jayaram (2008) is used to compute the expected value of epsilon at other spectral periods.

(1) Constant Epsilon Spectrum

The constant epsilon spectrum is constructed by specifying a single value of epsilon for all periods (e.g. an 84th-percentile spectrum). To construct the constant epsilon spectrum the user provides the desired epsilon value and disables the method of conditional mean spectrum, as shown in Figure 26.

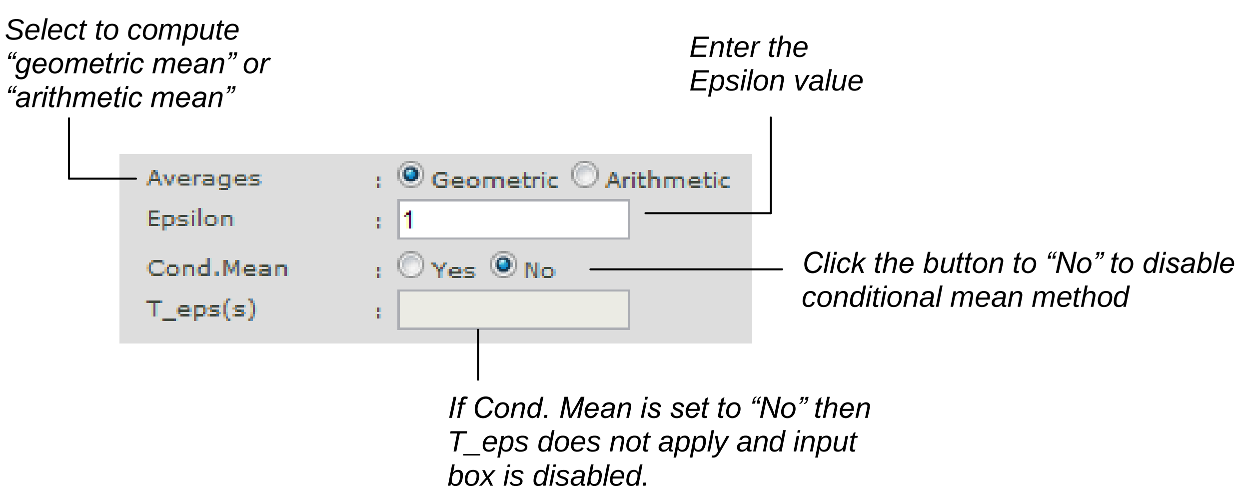


Figure 26: Constructing a Constant Epsilon Spectrum.

Figure 27 shows examples of constant epsilon spectra generated using the average of five NGA models and epsilon = 0, 1, and 2. Model parameters are specified as shown in Figure 24. Epsilon is changed to be 0, 1 and 2 for each case as shown in Figure 8. The three cases are plotted together in the same graph for easy comparison.

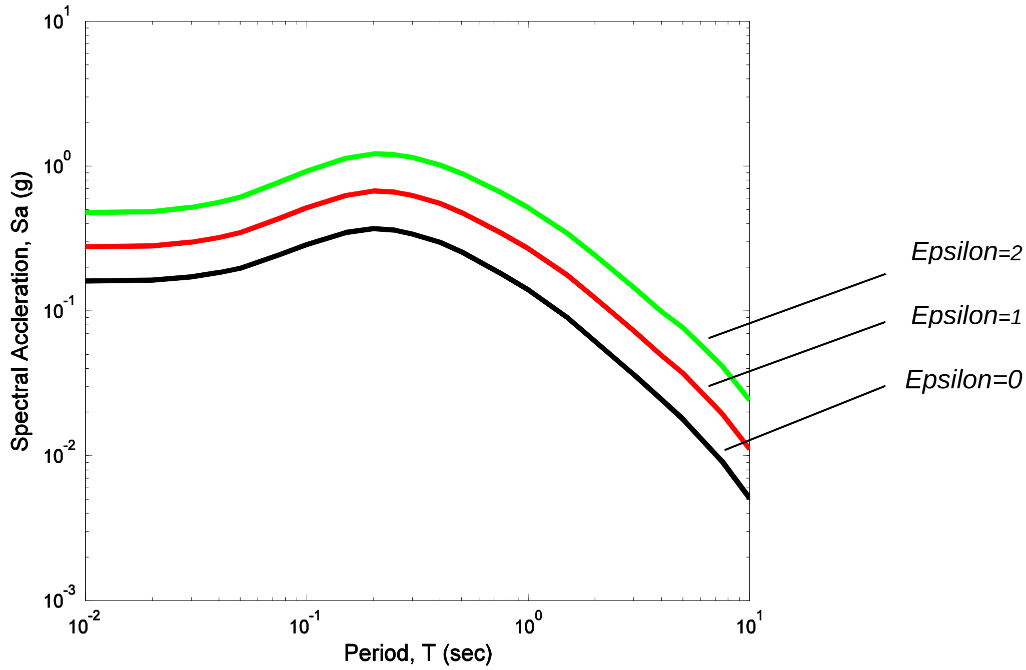


Figure 27: Example of Constant Epsilon Spectrum

(2) Conditional Mean Spectrum (CMS)

A conditional mean spectrum can be constructed using NGA models and the correlation coefficient model by Baker and Jayaram (2008) (see text of the report for a complete description). The inputs needed to construct a conditional mean spectrum are shown in Figure 28.

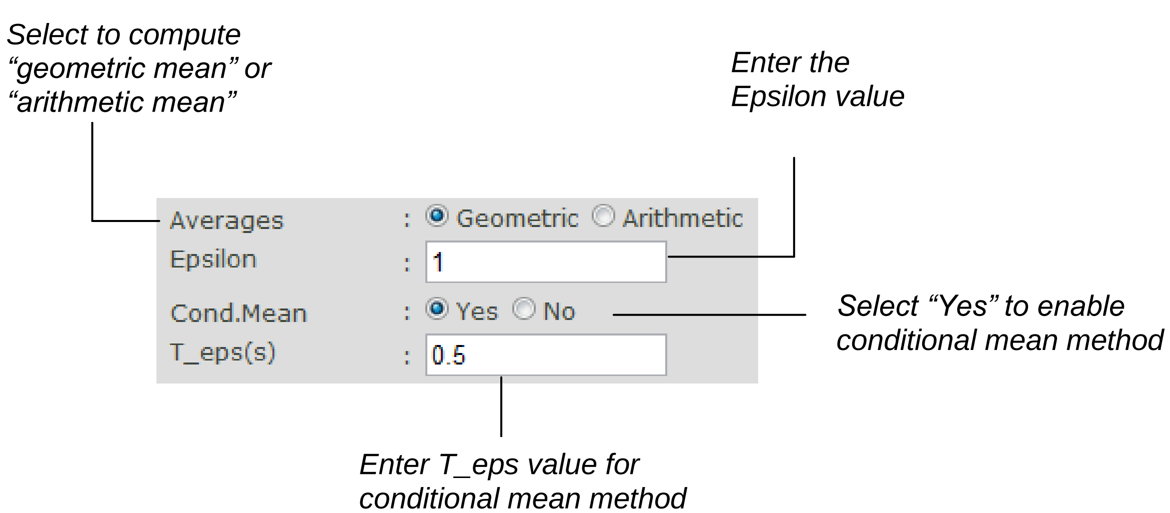


Figure 28: Input Needed to Construct a Conditional Mean Spectrum

Figure 29 shows an example of a conditional mean spectrum (CMS) created for an epsilon value of 1.0 at a spectral period of 0.5 seconds. Model parameters are specified as shown in Figure 24 using input parameters for the CMS are the same as shown in Figure 28. The solid black line shows the generated CMS for epsilon=1 and T_eps=0.5 sec. Constant epsilon spectra for epsilon=0, 1, as shown previously in Figure 27, are also plotted in Figure 29 for comparison with the CMS.

The value of epsilon may be selected in a variety of ways. One approach would be to use the results of epsilon deaggregation from a PSHA calculation. Alternatively, the user may specify a target spectral acceleration at T_eps and then enter trial values of epsilon until the resulting average conditional mean spectrum matches the target value.

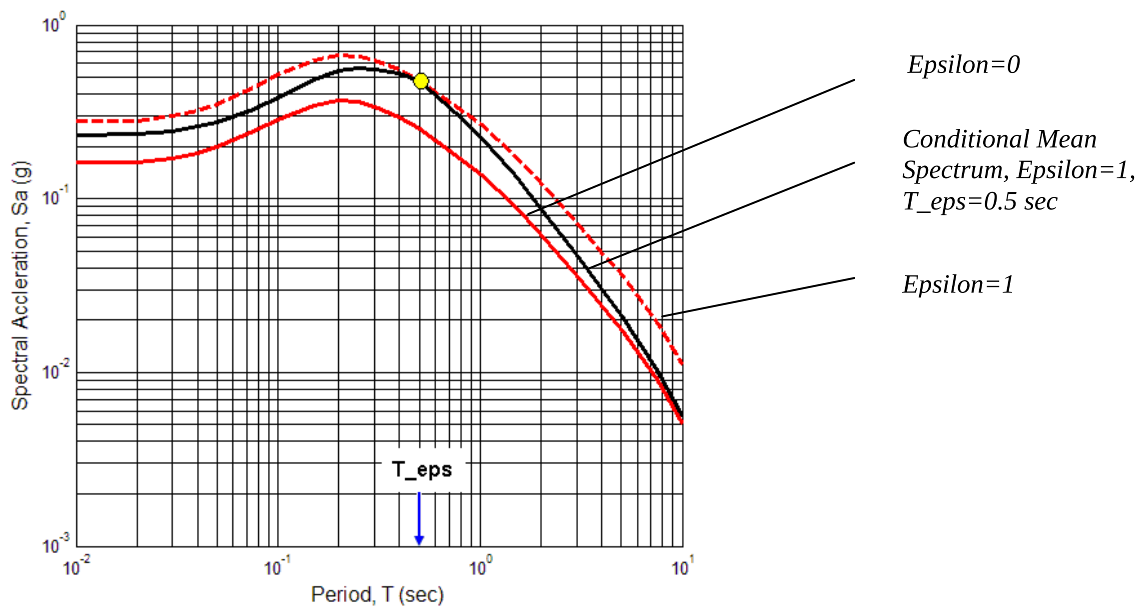


Figure 29: Example of Conditional Mean Spectrum

4.2 User Defined Spectrum

A user defined spectrum is any target response spectrum the user wishes to use. It may represent a uniform hazard spectrum from a PSHA or a scenario earthquake spectrum created using other ground motion models. **There is no limit for the number of spectral periods and spectral acceleration values that may be entered.**

Select a “User Defined Spectrum” model by clicking the drop menu (Location 1 in Figure 22) and select a “User Defined Spectrum” option.

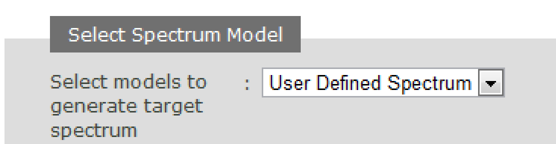


Figure 30: Selecting a User Defined Spectrum Model

4.2.1 Creating and Loading a User Defined Spectrum File

A file containing a user defined spectrum is created using a text editor. An example file is shown in Figure 31.

```
# User Specified Spectrum
# T(sec)   Sa(g)
# ------------------------------------
0.01       0.54
0.02       0.54186
0.075      0.8481
0.1        1.01966
0.2        1.31426
0.3        1.3162
0.5        1.10297
1          0.74228
1.5        0.5379
2.0        0.40813
3          0.24773
4          0.16592
10         0.05
```

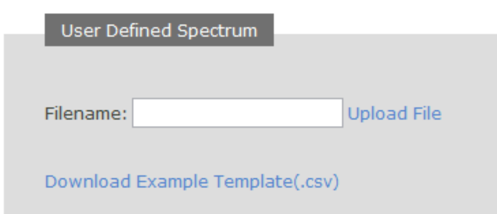
Comment lines are the lines that contain any characters (as long as it is not pure numbers)

Data field, each line contains spectral period (T) and spectral acceleration (SA) data in pairs, separated by blanks or tabs. There is no limit for the number of data that maybe entered.

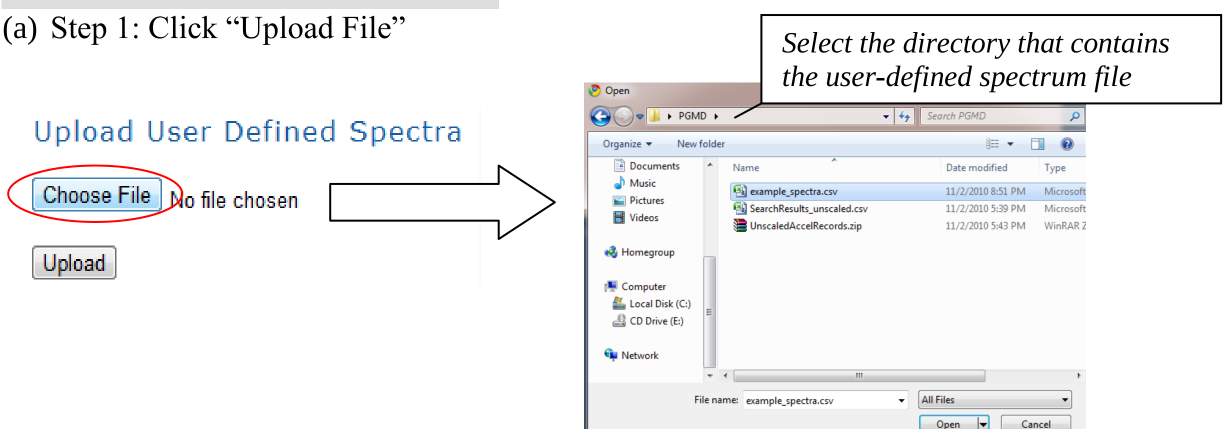
Figure 31: Example of User Defined Spectrum File

The user can also download an example file by clicking "Download Example Template (.csv)", make modifications, save it and then upload the modified file.

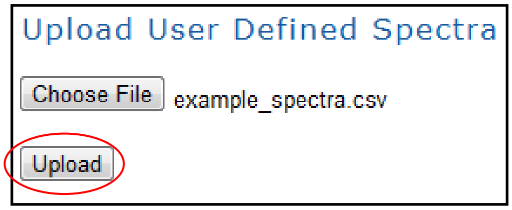
To load a user-defined spectrum, follow the steps from the following figure.



(a) Step 1: Click "Upload File"



(b) Step 2: Click "Choose File" to select from a directory

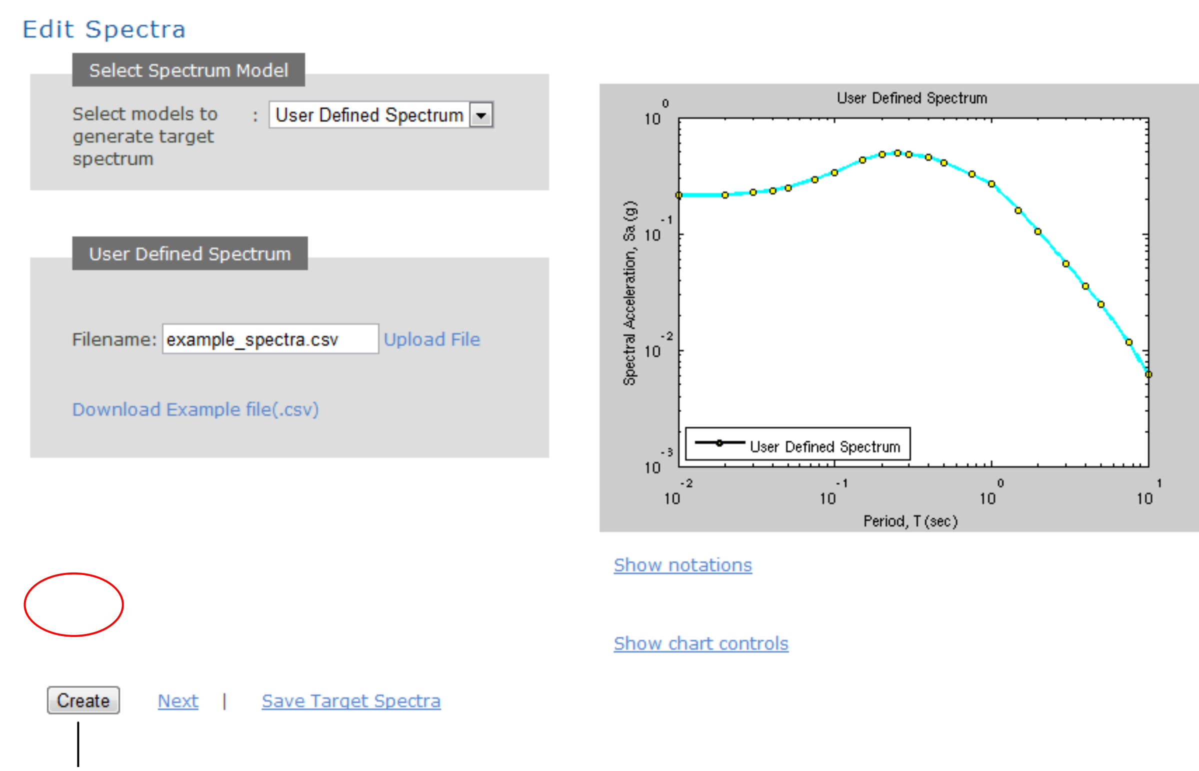


(c) Step 3: Click the “Upload” button

Figure 32: Selecting a User Defined Spectrum File From the File Menu

4.2.2 Generate User Defined Spectrum

Click **Create** button, and the user defined spectrum will be plotted in the plotting area, as shown in Figure 33.



Click to Create target spectrum

Figure 33: Plot of User Defined Spectrum Using Data from the Example File.

4.3 CODE SPECTRUM

The code specified design response spectrum is in accordance with ASCE Standard ASCE/SEI 7-05 specified in the "Minimum Design Loads for Buildings and Other Structures", published by the American Society of Civil Engineers, 2006. The code specification requires three points to construct the spectrum, as follows: site-adjusted short period (0.2 sec) spectral acceleration (S_{DS}), site-adjusted one-second period (1.0 sec) spectral acceleration (S_{D1}), and the transition period (T_L) between constant spectral velocity and constant spectral displacement regions of the spectrum. These parameters are illustrated in Figure 34.

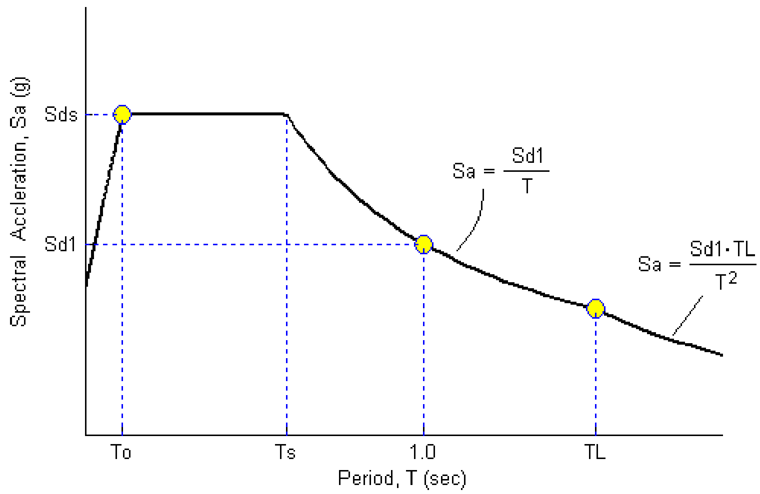


Figure 34: ASCE/SEI 7-05 Code Spectrum

The procedures, equations, and parameters for constructing each branch of the spectrum are given in ASCE Standard ASCE/SEI 7-05.

Example:

Step 1: To activate the function to generate a target spectrum according to the code specification, users need to select the spectrum model by selecting “ASCE Code Spectrum” from the menu at location 1 in Figure 22.

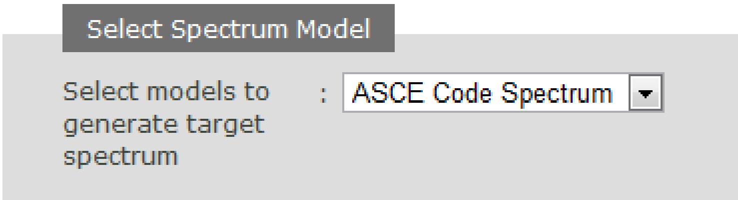


Figure 35: Selecting the ASCE Code Spectrum Model

Step 2: Key in Sds (g), Sd1 (g), TL (sec) in the Input Windows for the Code Spectrum

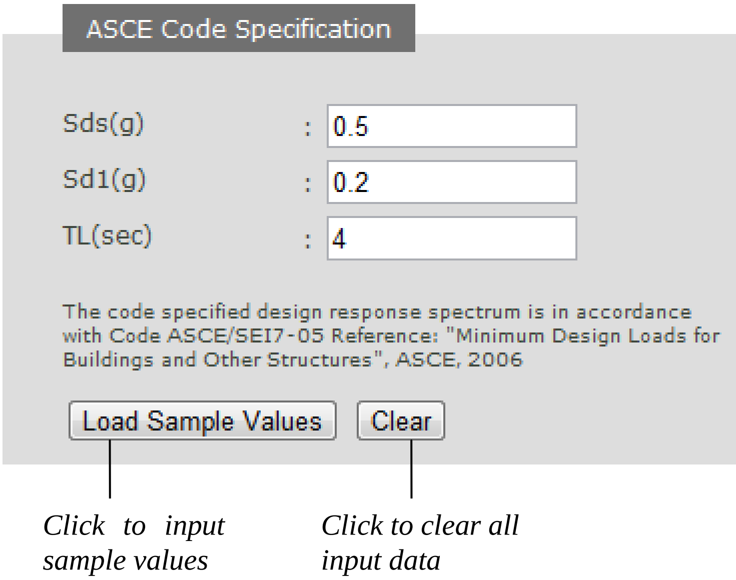


Figure 36: Input Needed to Construct a Code Spectrum.

Step 3: Press the **Create** Button.

Step 4: A target spectrum is then generated in the plotting area as illustrated in Figure 37.

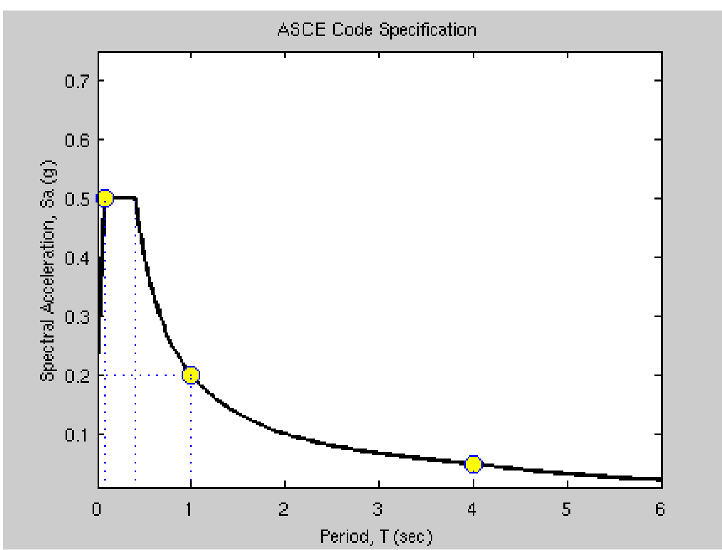


Figure 37: ASCE/SEI 7-05 Code Spectrum Created Using the Values Listed in Figure 36.

4.4 Chart Control Panel

The chart control panel becomes visible by clicking “Show chart controls” and it is used to provide options for plot adjustment. Figure 38 displays the layout of the chart control panel, and each of the functions will be described in the following:

(1) Drop menus are used to control the plot of the target spectrum: drop menu **A** to change the plot axis, e.g. from log-log plot to linear plot; drop menus **B** and **C** to select the color and style of the lines to be plotted.

(2) “Hold On” checkbox allows a new graph to be plotted on top of the previous plot for easy comparison. If Hold On box is checked, the plot will be displayed in the plot window without erasing the previous plot. If Hold On box is unchecked, each time the new plot is created, the previous one is erased. “Grid On” checkbox is to display the grid lines on the plot window. “Only Average” checkbox, if checked, displays only the average spectrum on the plot window if more than one PEER-NGA model is used. “Normalized” checkbox, if checked, will plot the normalized target spectrum (normalized with respect to PGA).

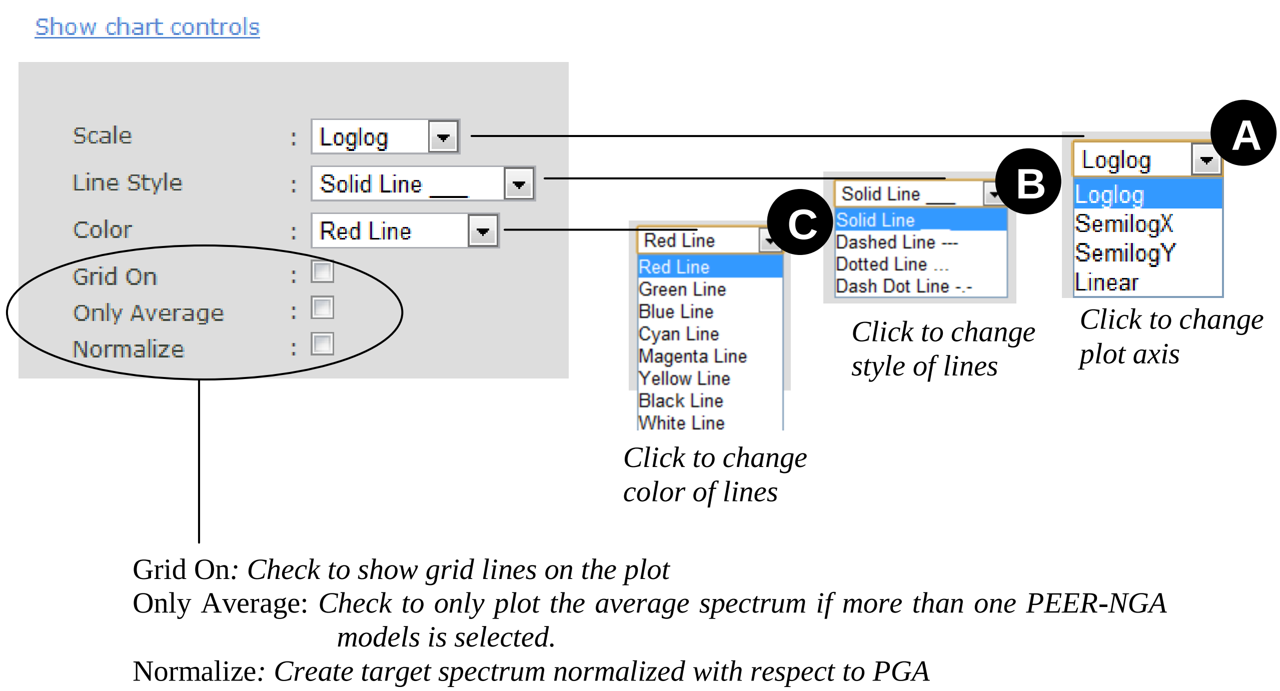
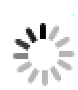


Figure 38: The Chart Control Panel

4.5 Create Spectrum

The “**Create**” button is used to create and plot the target spectrum using current spectrum model and parameters. A spinning wheel will appear while the data is being processed and plots are generated.



4.6 SAVE TARGET SPECTRUM

4.6.1 Save Target Spectrum Report

PGMD allows users to output the generated target spectrum in .csv format (Comma Separated Variables file) by clicking “Save Target Spectra” button in the lower left side of the window, as shown in Figure 39. The CSV format file can be directly opened by Microsoft Excel or any text editor, providing the most convenient way for data export.

Figure 40 demonstrates a DGML automatically generated target spectrum report using parameters prescribed in Figure 24. In this file, the parameters that are used in generating the target spectrum are listed. In this example, the V_{S30} value is annotated as “estimated”, and default values of $Z_{1.0}$ and $Z_{2.5}$ for A&S, C&Y and C&B model are reported separately. Spectrum values by individual NGA model together with the mean spectrum are listed for periods of 0.01, 0.02, 0.03, 0.04, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 7.5, and 10 seconds.

For a code-specified target spectrum, only the periods and spectrum values are reported. The exported values are interpolated at period intervals that are evenly spaced in log space, with 100 points per decade.

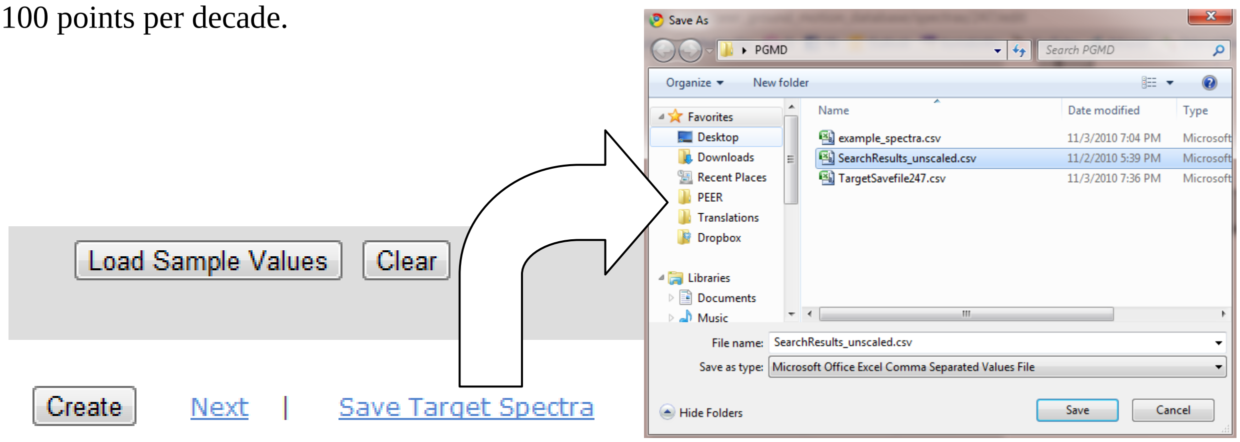
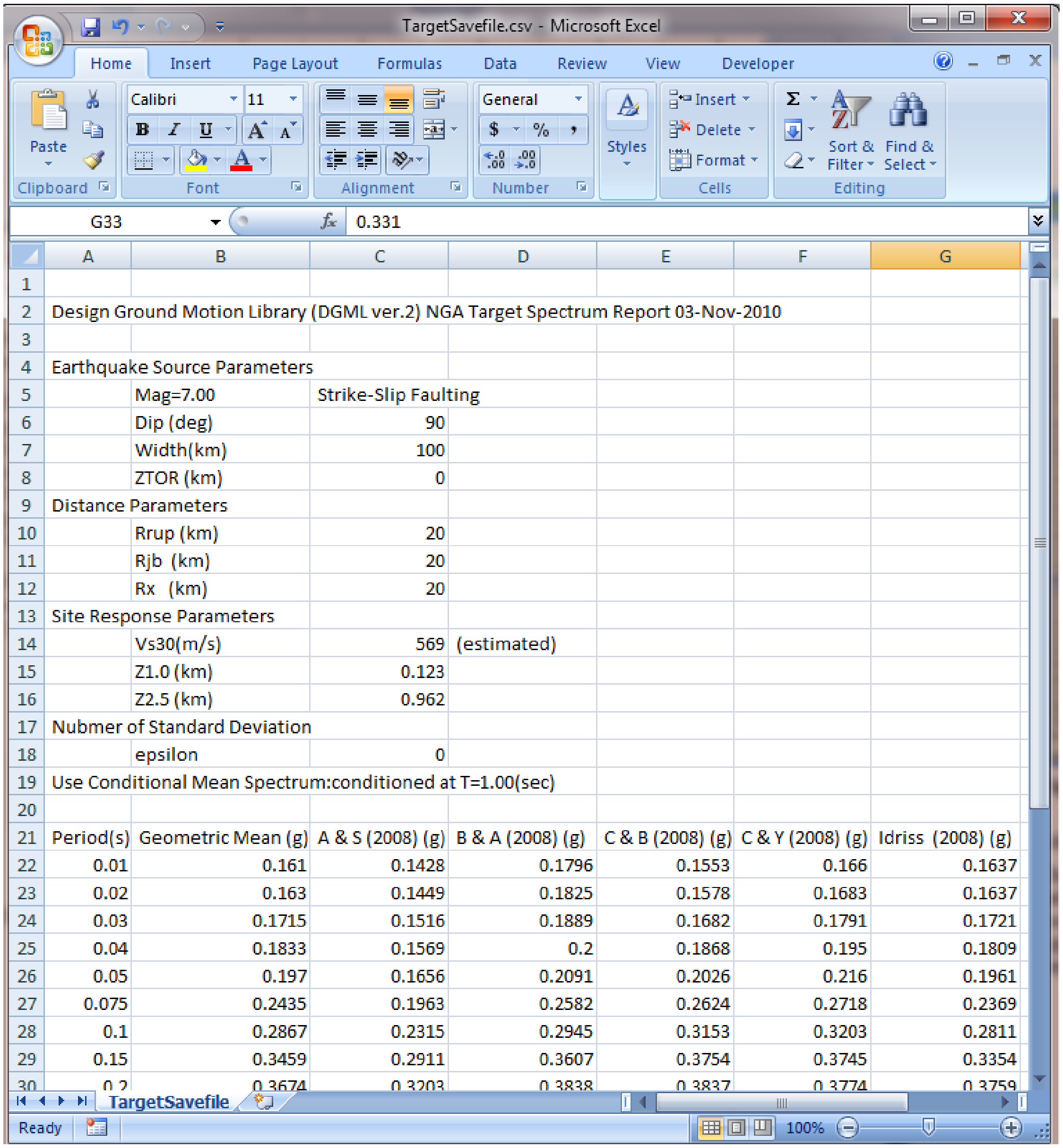


Figure 39: Click “Save Target Spectra” Button to Save Target Spectrum



	A	B	C	D	E	F	G
1							
2	Design Ground Motion Library (DGML ver.2) NGA Target Spectrum Report 03-Nov-2010						
3							
4	Earthquake Source Parameters						
5		Mag=7.00	Strike-Slip Faulting				
6		Dip (deg)	90				
7		Width(km)	100				
8		ZTOR (km)	0				
9	Distance Parameters						
10		Rrup (km)	20				
11		Rjb (km)	20				
12		Rx (km)	20				
13	Site Response Parameters						
14		Vs30(m/s)	569	(estimated)			
15		Z1.0 (km)	0.123				
16		Z2.5 (km)	0.962				
17	Nubmer of Standard Deviation						
18		epsilon	0				
19	Use Conditional Mean Spectrum:conditioned at T=1.00(sec)						
20							
21	Period(s)	Geometric Mean (g)	A & S (2008) (g)	B & A (2008) (g)	C & B (2008) (g)	C & Y (2008) (g)	Idriss (2008) (g)
22	0.01	0.161	0.1428	0.1796	0.1553	0.166	0.1637
23	0.02	0.163	0.1449	0.1825	0.1578	0.1683	0.1637
24	0.03	0.1715	0.1516	0.1889	0.1682	0.1791	0.1721
25	0.04	0.1833	0.1569	0.2	0.1868	0.195	0.1809
26	0.05	0.197	0.1656	0.2091	0.2026	0.216	0.1961
27	0.075	0.2435	0.1963	0.2582	0.2624	0.2718	0.2369
28	0.1	0.2867	0.2315	0.2945	0.3153	0.3203	0.2811
29	0.15	0.3459	0.2911	0.3607	0.3754	0.3745	0.3354
30	0.2	0.3674	0.3203	0.3838	0.3837	0.3774	0.3759

Figure 40: Example of PGMD Target Spectrum Report

4.6.2 Save Target Spectrum Plot

The spectrum plot can be saved to the disk as figure files. Right click mouse on the plot area. Left click the "Save Image As" on the popup window, select the proper directory, and enter the name of the graphic file to save. Figure 41 illustrates the steps to save the spectrum plot.

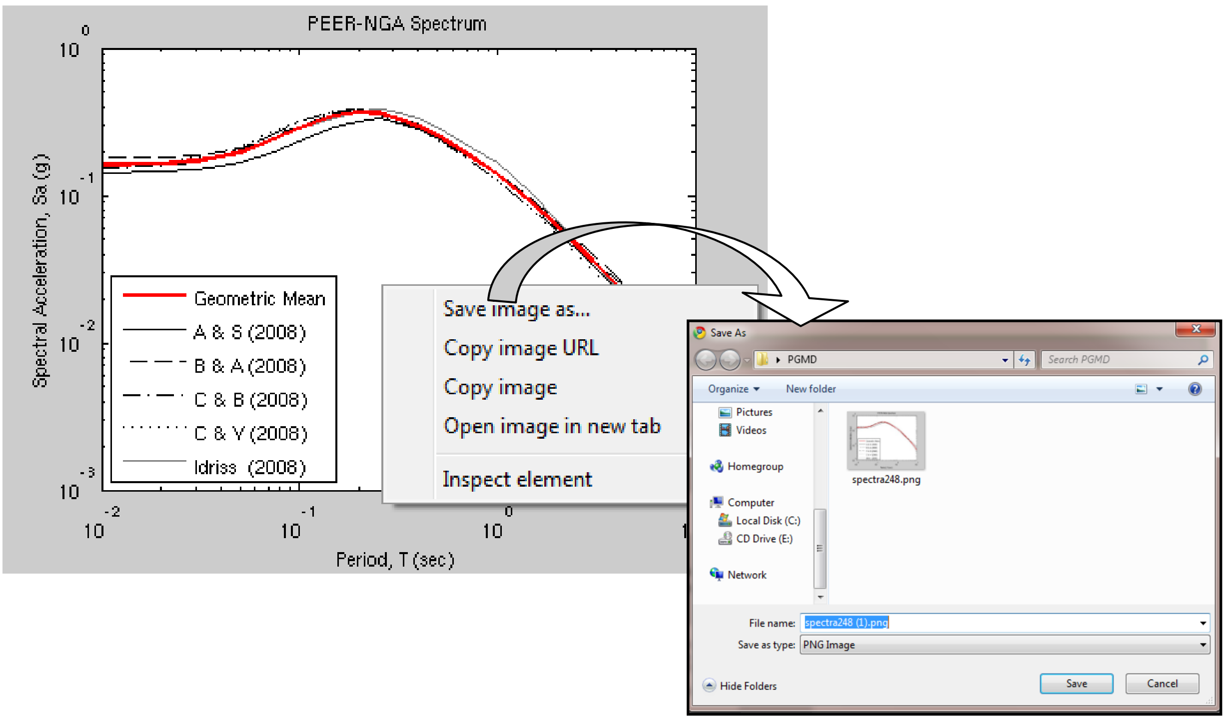


Figure 41: Save PGMD Target Spectrum Plot

4.7 Proceed to the Next Step

After the target spectrum is created using one of the three models, (1) PEER-NGA spectrum; (2) User defined spectrum; (3) ASCE/SEI Standard 7-05 code specified spectrum, click "Next" to go to the second step which is the search for compatible records based on acceptance criteria.

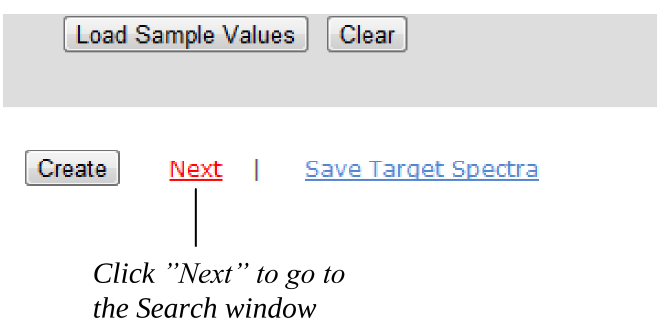


Figure 42: Click "Next" to go to the search window

.

5. SEARCH PEER DATABASE - SCALED SECTION

The PGMD SEARCH ENGINE window for the scaled section contains eight main parts, as labeled in Figure 43: (1) Search Engine to specify the record acceptance criteria and perform search over NGA database; (2) Specification of Weight Function used for scaling records; (3) Spectra plotting window; (4) Weight Function plot; (5) Acceleration/ Velocity/ Displacement time series plotting of a selected record; (6) Ground motion record information output list; (7) Chart control panel for line styles; (8) Buttons to save the search results and selected acceleration time series files; (9) Google map to display basic information about each record checked.

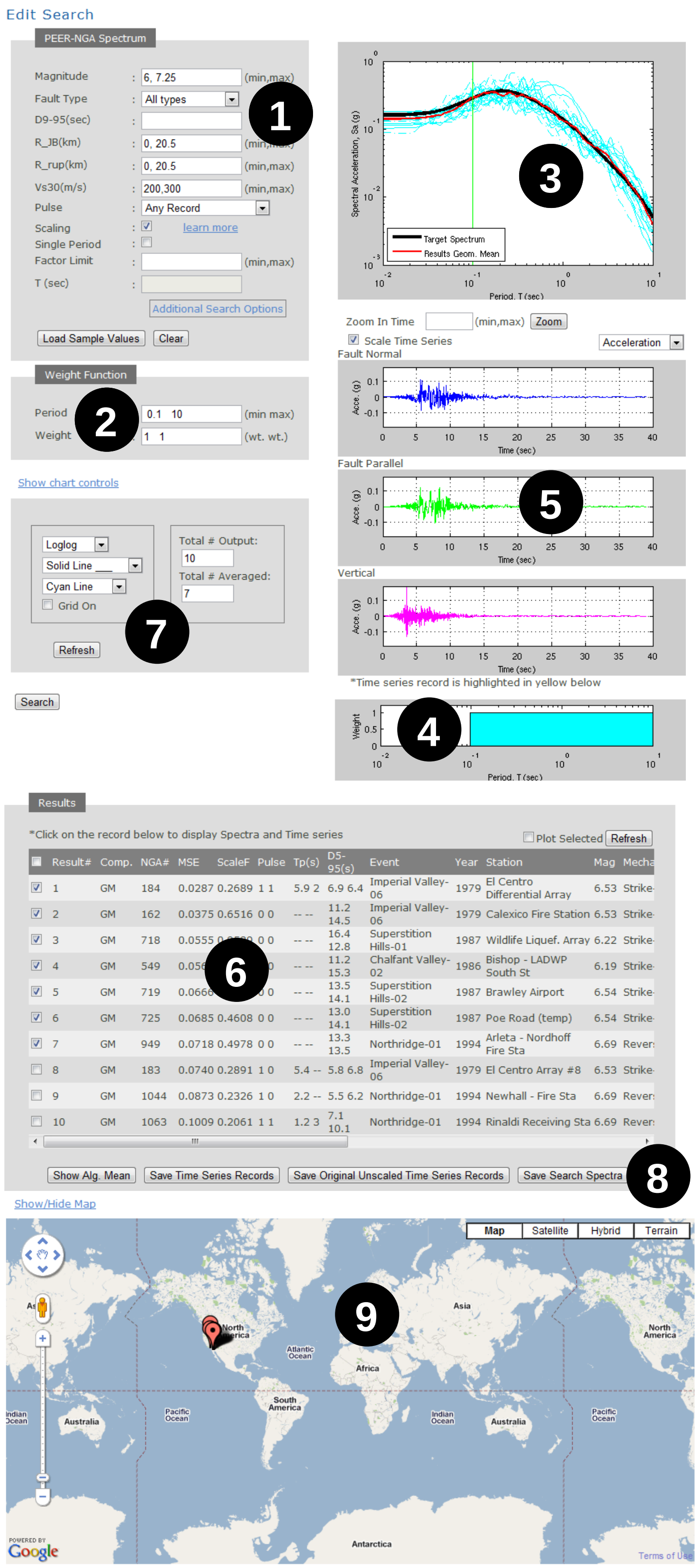


Figure 43: Scaled Section Search Engine Window

5.1 SWITCH BETWEEN MAIN AND SUPPLEMENTARY SEARCH ENGINES

PGMD provides two types of search engines. Figure 44 illustrates the switch between two search engine interfaces by clicking "Additional Search Options" button. The main search engine searches the database according to the specified acceptable ranges for the characteristics of the recordings (e.g. the appropriate magnitude, distance range etc, termed as "acceptance criteria"). The supplementary search engine searches the database according to specified NGA sequence numbers, event names, and station names. The two search engines are described in the following sections. By default, PGMD displays the main search engine.

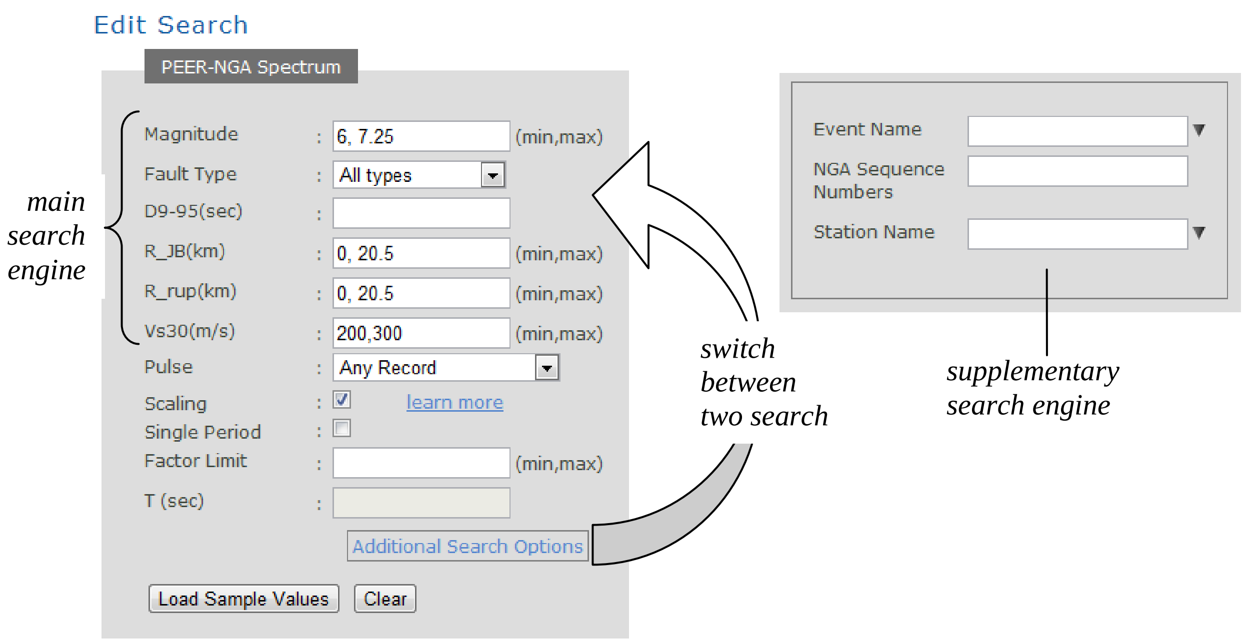


Figure 44: Switch between Main and Supplementary Search Engines

5.2 MAIN SEARCH ENGINE: SEARCH ACCORDING TO ACCEPTANCE CRITERIA

The acceptance criteria for recordings are entered in the search engine data boxes shown in Figure 45 (location 1 in Figure 43). As described in Sec. 3.1.2, acceptance criteria are specified by indicating the allowable range or restriction for the parameters listed in Table 1. In addition, the scaled section includes the additional parameters listed in Table 4 below. Any recording satisfying these criteria will be passed on to the second stage of comparison with the target spectrum.

Data field input format is the same as described in Sec. 3.1.2.

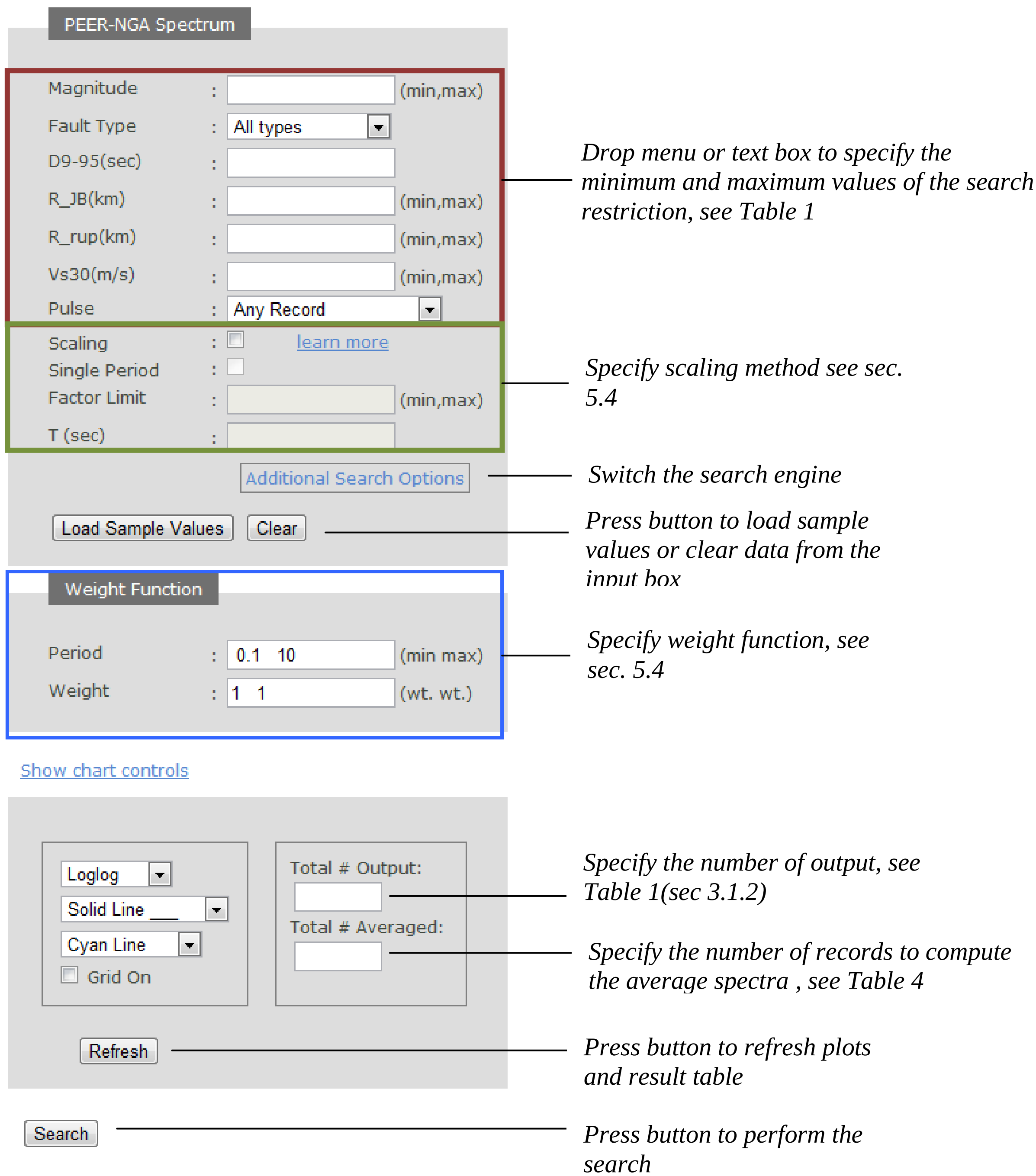


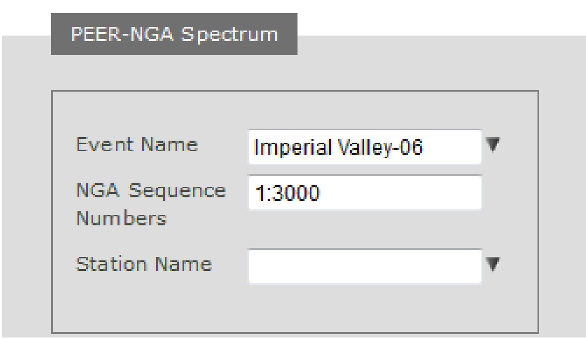
Figure 45: Main Search Engine (Default) User Interface for Scaled Section.

Table 4: Additional Parameters for PGMD Search Engine – Scaled Section

Data Field	Explanations
Factor Limit	Restrict range of scale factors, input in the format of [min, max], or leave as blank for no restriction. The parameter is applicable only if "scaling" is checked and "single period" is unchecked (i.e. the records are scaled, but are not scaled to a single period).
T (sec)	The period whose target spectral value all records are scaled to. The parameter is applicable only if "scaling" is checked and "single period" is also checked (i.e. the records are scaled, but are scaled only to a single period).
Period Array	A real number sequence of periods used to specify the weight function. The number sequence is in ascending order between [0.01, 10].
Weight Array	A real number sequence of weights used to specify the weight function. The number sequence is in one-to-one correspondence to that of the Period Array.
Total Num. Averaged	Specify the total number of record spectra to compute the average spectra. The number will be automatically reset to the maximum possible if the total output record number is less.

5.3 SUPPLEMENTARY SEARCH ENGINE FOR SCALED SECTION

Supplementary Search Engine for the Scaled Section has the same features as the Main Search Engine for the Unscaled Section (Sec. 3.1.1). Figure 46 illustrates an example using the supplementary search engine to search and scale all "Imperial Valley-06" event from NGA #1-#3000. Please note that PGMD limits the maximum number of output to be less than 100 to avoid abuse of the program. "Total Num. Averaged" (Figure 45) is set by the user.



Drop menu or text box to specify the Event Name, NGA Sequence Numbers and Station Name

Figure 46: Supplementary Search Engine User Interface for Scaled Section.

5.4 SPECIFY SCALING METHOD AND WEIGHT FUNCTION

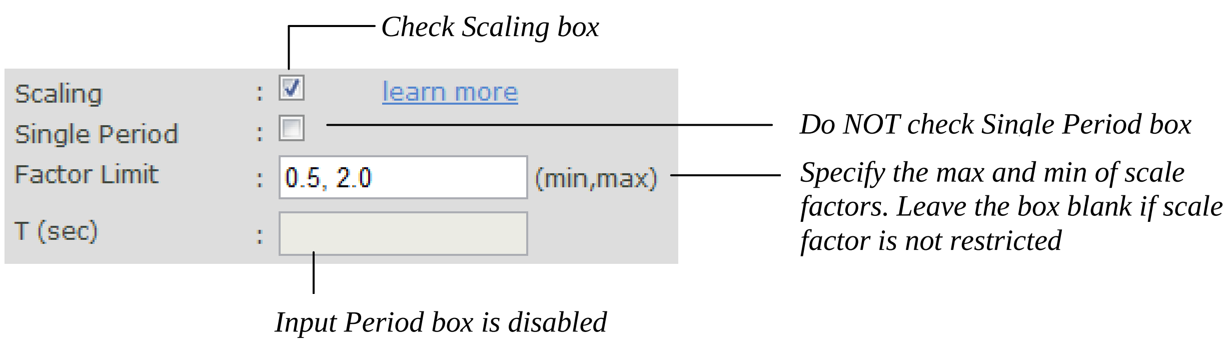
The degree of similarity between the target and recording spectra is measured by the mean squared error between the two spectra. The user has several options for scaling the recordings before computation of the mean squared error. These are described in the following section.

5.4.1 Scaling the Records

Record scaling in the PGMD is accomplished by applying a linear scale factor that does not alter the relative frequency content of the acceleration time series, and thus does not change the shape of the response spectrum of the time series. Two options are provided for scaling the records to match the target response spectrum. The user also has the option to use unscaled records.

(1) Scale the record to match the target spectrum over a period range

In this approach the record (or pair of records) is scaled by a factor that minimizes the mean squared error between the spectrum (spectra) of the scaled record(s) and the target spectrum. Calculation of the mean squared error is described in the main text of the PGMD technical report.



Check the *Scaling* box, do NOT check the *Single Period* box, and specify the limits on scale factors, if desired. In this scheme, the scale factor is computed to minimize the weighted squared residuals between the scaled record and the target spectrum (see Section 2.3.2 of the technical report). Specification of the weight function is described in Section 5.4.2 of this manual. If the range (minimum, maximum) of scale factor is specified by the user, and the computed scale factor is greater (or less) than the specified maximum (or minimum), then the scale factor takes the maximum (minimum) value. If the factor limit is left blank, no restriction is imposed on the scale factor. The above example limits the minimum scale factor to 0.5, and maximum scale factor to 2.0.

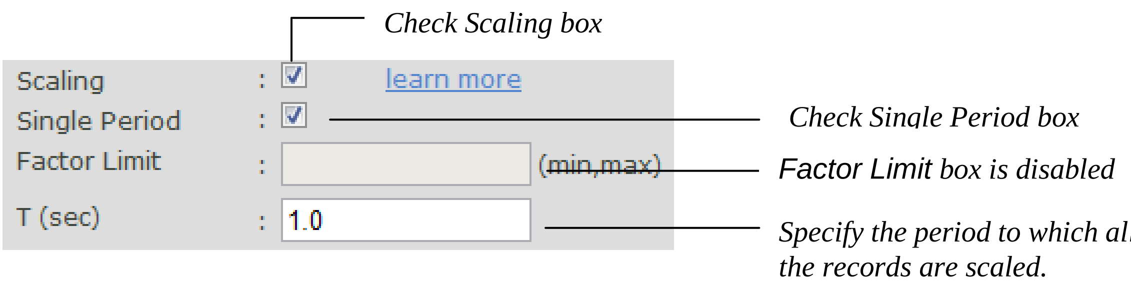
(2) Scale the records to match the target spectrum to a single period

In this approach, the records are scaled to match the target spectrum at a specific spectral period, called *T* (sec). In this scheme, the scale factor (f) is computed such that the record spectrum matches the target spectrum at the single period *T*, i.e.,

$$f = \frac{SA^{target}\ (T)}{SA^{record}\ (T)}$$

The mean squared error is computed for the scaled record as described in Section 2.3.2 of the technical report.

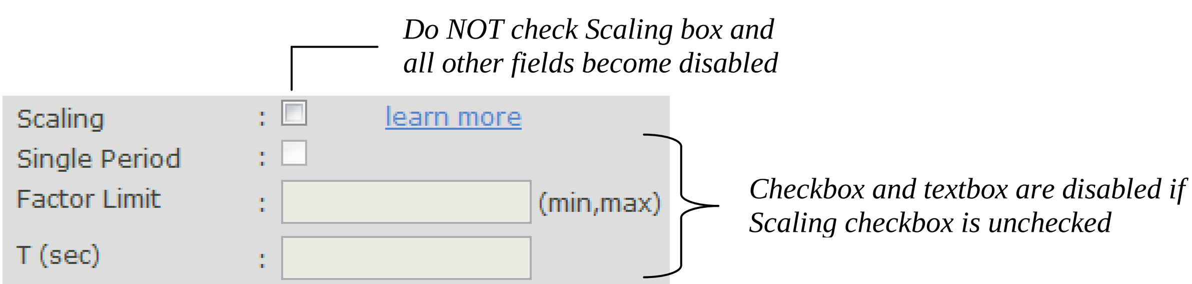
To scale the records to match the target spectrum to a single period of *T*, check the *Scaling* and *Single Period* checkbox, and specify the *T* value as follows,



The above example shows all records are to be scaled to match the target spectrum at period 1.0 sec.

(3) No scaling

The third option is to consider only unscaled records. The mean squared error between the spectrum (spectra) of the recordings and the target is computed as described in Section 2.3.2 of the technical report with the scale factor set to 1.0.



Do not check *Scaling* checkbox to disable scaling method. Original records are used in this case.

5.4.2 Weight Function (Period Array and Weight Array)

A weight function is used to compute the scale factor for scaling option 1 in Section **5.4.1** and in the computation of the mean squared error for all scaling options. We emphasize that the user needs to specify the weight function even if the records are to be scaled to match the target spectrum at a single period, or if there is no scaling at all. In the last two cases, although the weight function is not involved in computing the scale factors, it is used to compute the mean squared error to order the results with respect to degree of similarity of target spectrum and spectra of recordings.

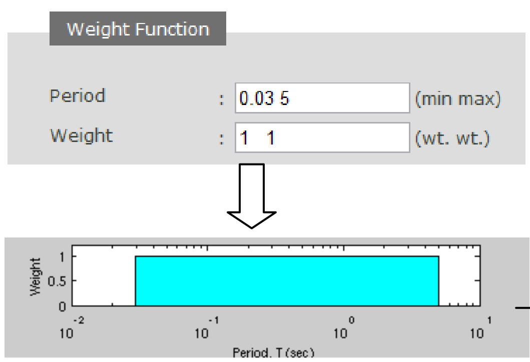
The user needs to specify *Period Array* and *Weight Array* to construct the weight function. The

Period Array or the *Weight Array* each has at least two data points. The *Period Array* is a period sequence (T_1, T_2, … T_n) in ascending order between [0.01,10], with each element delimitated by space or comma. The *Weight Array* data set is a sequence of non-negative numbers that have a one-to-one correspondence to the *Period Array* data set, and thus shall have the same number of elements (W_1, W_2, … W_n). Weights beyond the range of the *Period Array* are automatically set to zero.

In PGMD, the weight function specified by Period Array and Weight Array is discretized by linearly interpolating over evenly-spaced discrete period points in log scale. To maintain sufficient accuracy, one log-cycle is discretized by 100 points. Therefore, there are 301 discrete period points (end-points included) in total to range from 0.01-10 sec. The weight function only represents relative weights assigned to various discrete periods and are normalized in the program such that the summation of the weight function over discrete period points equals unity. Therefore, the absolute value of the weight function is immaterial.

The following three examples illustrate input of the weight function and the visualization produced by the PGMD web application.

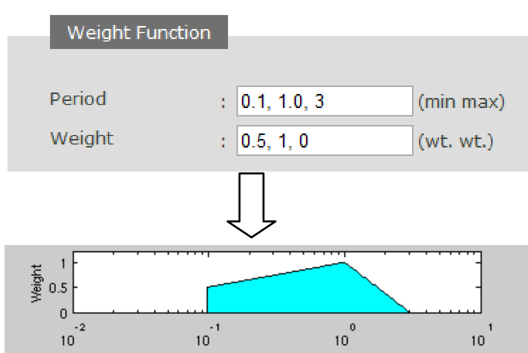
Example 1



Equal weight between period 0.03 sec. to 5.0 sec.

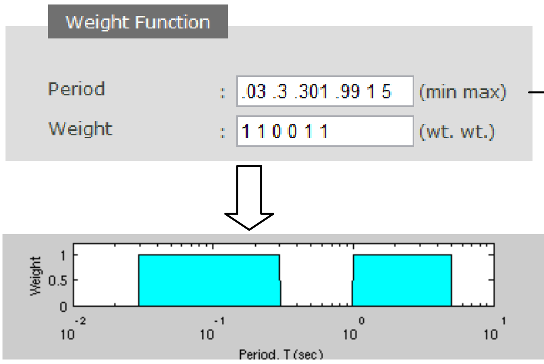
The weight function is visualized in Area 4 of Figure 24 when the Search button in Figure 26 is pressed.

Example 2



More weight is put on the short period range (0.1-1 sec) than long period range (1-3 sec)

Example 3



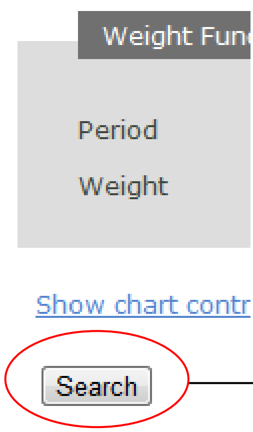
Discrete weight on the short period range (0.03-0.3 sec) and long period range (1-5 sec). Because the Period Array needs to be a monotonically increasing sequence, step function should be approximated by a very steep ramp, as illustrated.

Figure 47: Examples of Specifying Weight Function

5.5 Perform the Search

5.5.1 Search for Records and Calculate Average Spectrum

Once the search restriction, scaling method and weight function are specified, press "*Search*" button to perform the search.



Press button to perform the search

The best 30 (which is the default number in *Total # Output* box) records will be displayed for inspection, and the best 7 records (which is the default number in *Total # Averaged* box) are used to compute the average spectrum. If the total number of records that satisfy the acceptance criteria is less than the value of *Total # Output* specified by the user, the value of *Total # Output* is automatically reset to the maximum number of acceptable recordings in the database. **PGMD restricts the display of outputs up to 50 records** to avoid abuse of the program.

The spectra for all 30 output recordings will be displayed in the spectrum plot window together with the average spectrum. Both the geometric mean and algebraic mean of the selected number of spectra are plotted against the target spectrum, see Figure 48 for an example.

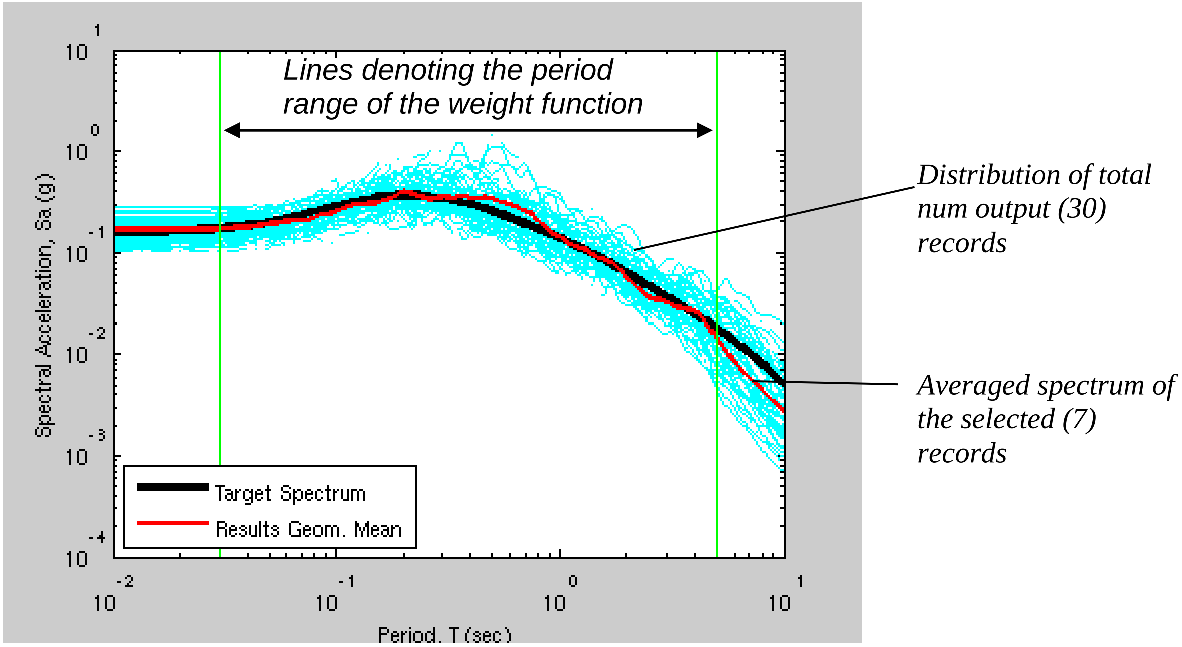
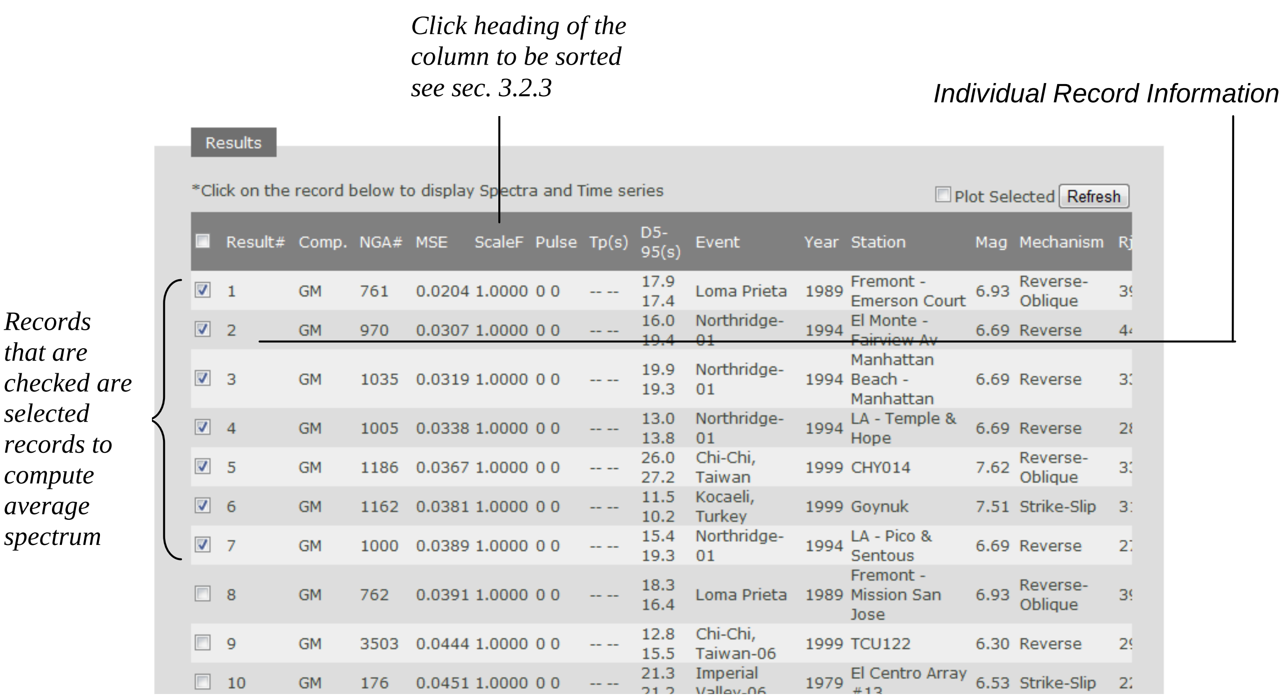


Figure 48: Example of Average Spectrum of Selected Records

5.5.2 List the Search Result

PGMD lists the search results in the *Results tablet window* for the total number of output records specified by users. The record list is ranked in order of increasing MSE.



	Result#	Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanism	Rj
☑	1	GM	761	0.0204	1.0000	0 0	-- --	17.9 17.4	Loma Prieta	1989	Fremont - Emerson Court	6.93	Reverse-Oblique	3
☑	2	GM	970	0.0307	1.0000	0 0	-- --	16.0 19.4	Northridge-01	1994	El Monte - Fairview Av	6.69	Reverse	4
☑	3	GM	1035	0.0319	1.0000	0 0	-- --	19.9 19.3	Northridge-01	1994	Manhattan Beach - Manhattan	6.69	Reverse	3
☑	4	GM	1005	0.0338	1.0000	0 0	-- --	13.0 13.8	Northridge-01	1994	LA - Temple & Hope	6.69	Reverse	2
☑	5	GM	1186	0.0367	1.0000	0 0	-- --	26.0 27.2	Chi-Chi, Taiwan	1999	CHY014	7.62	Reverse-Oblique	3
☑	6	GM	1162	0.0381	1.0000	0 0	-- --	11.5 10.2	Kocaeli, Turkey	1999	Goynuk	7.51	Strike-Slip	3
☑	7	GM	1000	0.0389	1.0000	0 0	-- --	15.4 19.3	Northridge-01	1994	LA - Pico & Sentous	6.69	Reverse	2
☐	8	GM	762	0.0391	1.0000	0 0	-- --	18.3 16.4	Loma Prieta	1989	Fremont - Mission San Jose	6.93	Reverse-Oblique	3
☐	9	GM	3503	0.0444	1.0000	0 0	-- --	12.8 15.5	Chi-Chi, Taiwan-06	1999	TCU122	6.30	Reverse	2
☐	10	GM	176	0.0451	1.0000	0 0	-- --	21.3 21.2	Imperial Valley-06	1979	El Centro Array #13	6.53	Strike-Slip	2

Figure 49: Results Table Window

Since user has specified *Total Num Averaged* (=7), the first 7 records (NGA #s 761, 970, 1035, 1005, 1186, 1162, 1000) in the list are selected to compute the average spectrum, **with their checkbox checked in front of each selected record**. The user can manually check or uncheck an individual record from the list of output records, click *Refresh* and the Resutls Geom. Mean plot (Fig. 48) will only consider the checked records.

The listed information for each record is tabulated in Table 5 and Table 2 (Sec 3.2.2).

Table 5. Additional Record Information of PGMD Search Result – Scaled Section

✓	**The check mark (✓) is used to designate the record is selected to compute the averaged design spectrum.**
MSE	Computed Mean Squared Error (MSE) of the selected record with respect to the target spectrum.
ScaleF	Scale factor of the record computed by DGML
FN Acc. File Name FP Acc. File Name	The FN/FP components acceleration time series record file name. The file names for both FN FP components are given (labeled as "FN Acc. File Name" and "FP Acc. File Name", respectively).
Vertical Acc. File Name	The vertical acceleration time series record file name. If the vertical file is missing, the file name is displayed as "nonexistent".

5.6 SELECTION AND EVALUATION OF RECORDS – SCALED SECTION

Features such as plotting response spectrum of individual or multiple records and display location of selected earthquake on Google map are described in Section 3.3.1 through Section 3.3.3.

5.6.1 Highlight Response Spectrum and Time Series of Records

The response spectrum and acceleration, velocity, and displacement time series for scaled individual records can be easily visualized as described in Section 3.3.4. The following example shows a particular record (NGA#162) selected. Record #162 is ranked 2nd in terms of closeness of the spectrum shape to the target spectrum, where geometric mean of the FN and FP components (Comp.=GM) are used to calculate the scale factor and MSE. The resulting scale factor (ScaleF) has the value of 0.6516. The pulse indicator shows that both components of this record are not pulse-like (Pulse=0 for both FN FP components).

Results

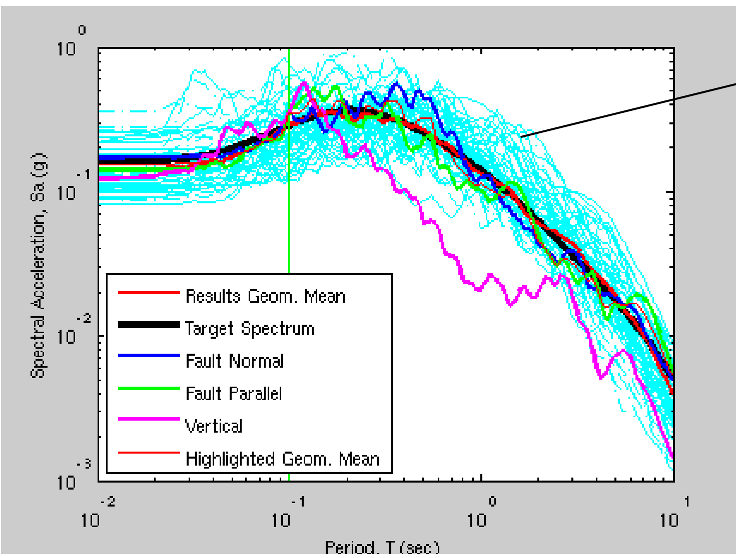
*Click on the record below to display Spectra and Time series

Plot Selected | Refresh

☐	Result#	Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanis
☑	1	GM	184	0.0287	0.2689	1 1	5.9 2	6.9 6.4	Imperial Valley-06	1979	El Centro Differential Array	6.53	Strike-Slip
☑	2	GM	162	0.0375	0.6516	0 0	-- --	11.2 14.5	Imperial Valley-06	1979	Calexico Fire Station	6.53	Strike-Slip
☑	3	GM	718	0.0555	0.9589	0 0	-- --	16.4 12.8	Superstition Hills-01	1987	Wildlife Liquef. Array	6.22	Strike-Slip
☑	4	GM	549	0.0564	0.6966	0 0	-- --	11.2 15.3	Chalfant Valley-02	1986	Bishop - LADWP South St	6.19	Strike-Slip
☑	5	GM	719	0.0666	1.0407	0 0	-- --	13.5 14.1	Superstition Hills-02	1987	Brawley Airport	6.54	Strike-Slip

Click to highlight an individual record

a) Highlight an Individual Record on the Results Table



Distribution of total num output (30) records

b) Plot of FN, FP, Vertical and Geometric Mean of highlighted record

Figure 50: Highlight the Response Spectrum of an Individual Record

In addition to the geometric mean of the checked records (7), PGMD plots the geometric mean of the FN and FP of the highlighted record (NGA# 162), the Target Spectrum and the three components of the record (i.e. FN, FP and Vertical).

Once an individual record is highlighted, the **scaled** acceleration/velocity/displacement time series is automatically plotted in *Time Series Plot Window*. One can select the drop menu to plot acceleration or velocity or displacement time series as described in Section 3.3.5 and Section 3.3.6. The user can plot the unscaled time series by unchecking the Scale Time Series box.

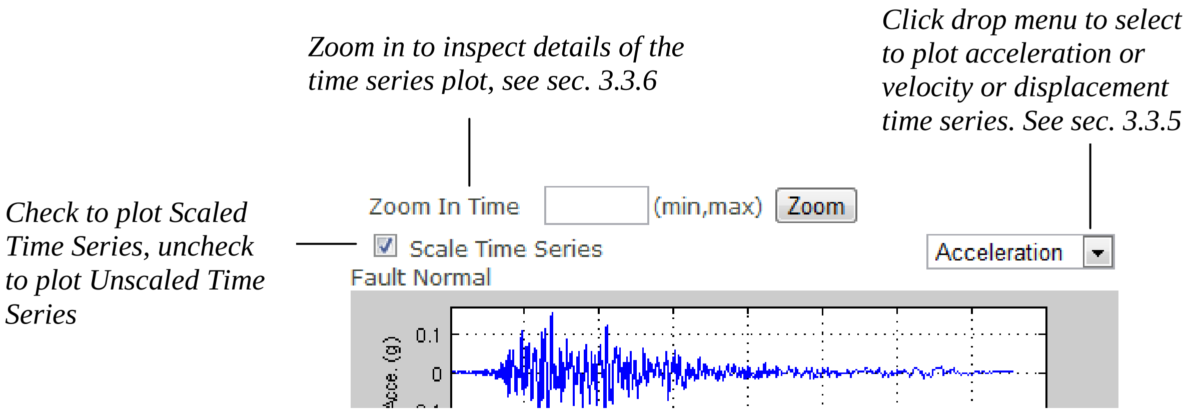


Figure 51: Option to Display Scaled or Unscaled Time Series Plots

5.6.2 Plot Algebraic Mean of Selected Records

The algebraic mean of the FN and FP of selected records can be inspected. The user first check the records and then press *Show Alg. Mean* to view the algebraic mean plot as shown in the example bellow.

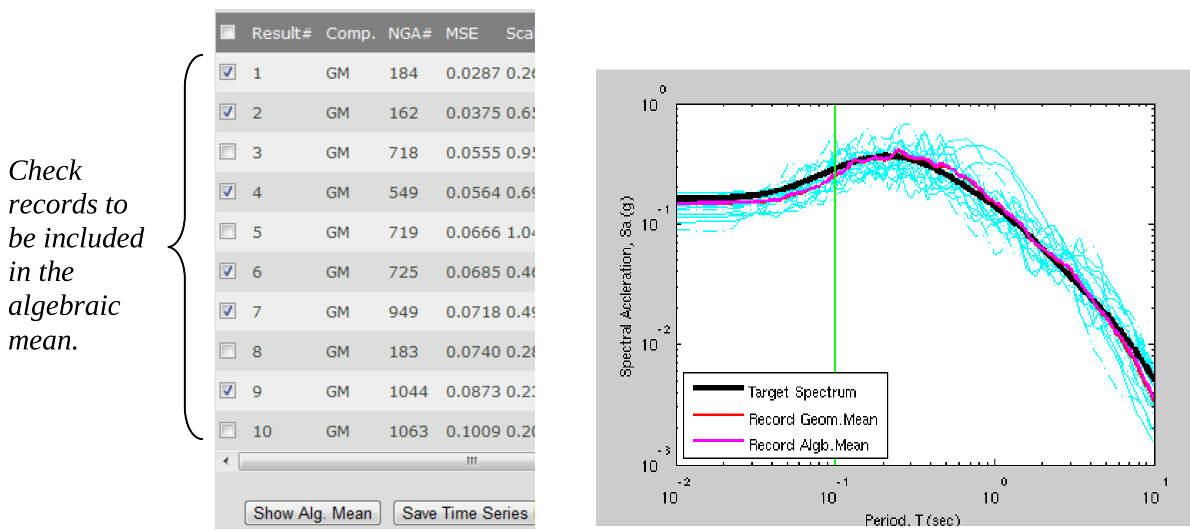


Figure 52: Plot of Algebraic Mean of Selected Records

5.7 CHART CONTROL

In addition to the functionalities to manipulate the spectrum plot summarized in Sec. 3.4.1 and 3.4.2 for the unscaled section, the Chart Controls panel of the scaled section has the *Total # Averaged* input box which is used to compute the average spectrum (see Sec. 5.5.2).

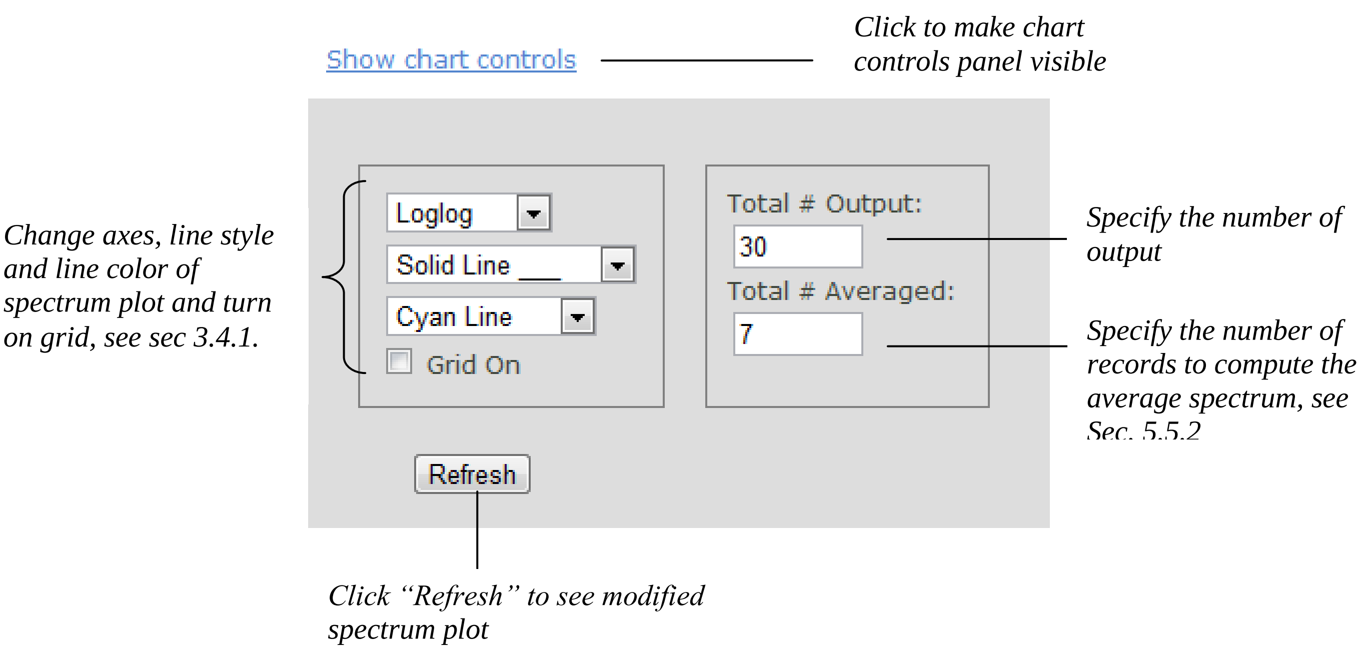


Figure 53: Chart Control Panel – Scaled Section

5.8 SAVE PGMD SEARCH RESULT - SCALED SECTION

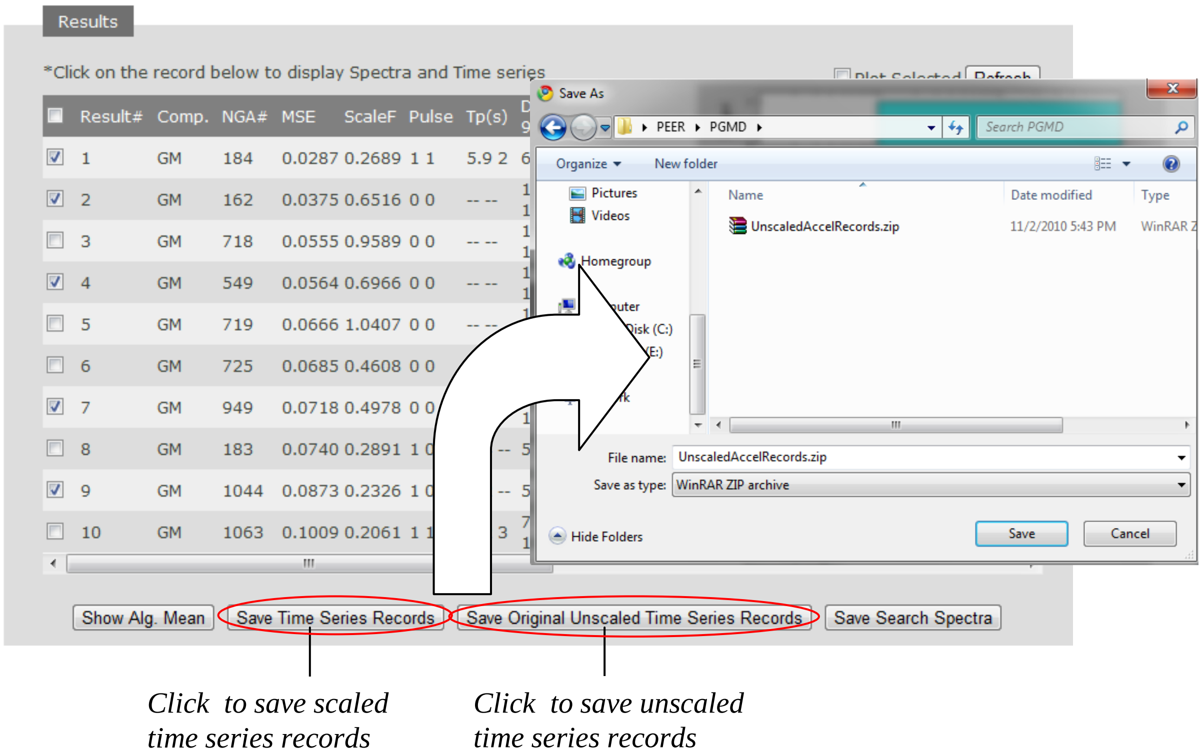
5.8.1 Save Scaled and Unscaled Acceleration Time Series Files

PGMD allows users to save the selected scaled and unscaled acceleration time series file. The steps are illustrated in Figure 54.

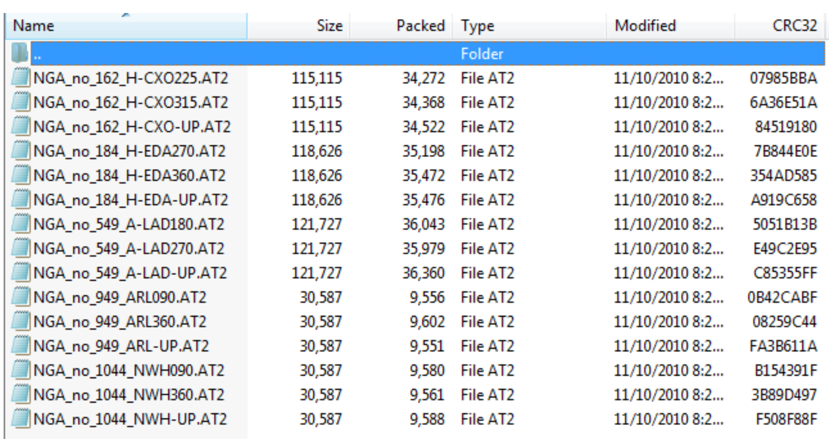
Step (1): user checks the record to be saved (for this example NGA# 184, 162, 549, 949, 1044). The horizontal and vertical time series files will be saved.

Step (2): click "*Save Time Series Records*" to save the scaled time series records or/and click the "*Save Original Unscaled Time Series Records*" to save the unscaled time series records. A pop-up window allows the user to specify the save directory and file name of the compressed time series files.

Step (3): extract the time series file. The file name assigned uses the convention of "NGAnumber_filename" to distinguish each record as it has a unique NGA number.



(a) Step (1) and (2)



Name	Size	Packed	Type	Modified	CRC32
..			Folder		
NGA_no_162_H-CXO225.AT2	115,115	34,272	File AT2	11/10/2010 8:2...	07985BBA
NGA_no_162_H-CXO315.AT2	115,115	34,368	File AT2	11/10/2010 8:2...	6A36E51A
NGA_no_162_H-CXO-UP.AT2	115,115	34,522	File AT2	11/10/2010 8:2...	84519180
NGA_no_184_H-EDA270.AT2	118,626	35,198	File AT2	11/10/2010 8:2...	7B844E0E
NGA_no_184_H-EDA360.AT2	118,626	35,472	File AT2	11/10/2010 8:2...	354AD585
NGA_no_184_H-EDA-UP.AT2	118,626	35,476	File AT2	11/10/2010 8:2...	A919C658
NGA_no_549_A-LAD180.AT2	121,727	36,043	File AT2	11/10/2010 8:2...	5051B13B
NGA_no_549_A-LAD270.AT2	121,727	35,979	File AT2	11/10/2010 8:2...	E49C2E95
NGA_no_549_A-LAD-UP.AT2	121,727	36,360	File AT2	11/10/2010 8:2...	C85355FF
NGA_no_949_ARL090.AT2	30,587	9,556	File AT2	11/10/2010 8:2...	0B42CABF
NGA_no_949_ARL360.AT2	30,587	9,602	File AT2	11/10/2010 8:2...	08259C44
NGA_no_949_ARL-UP.AT2	30,587	9,551	File AT2	11/10/2010 8:2...	FA3B611A
NGA_no_1044_NWH090.AT2	30,587	9,580	File AT2	11/10/2010 8:2...	B154391F
NGA_no_1044_NWH360.AT2	30,587	9,561	File AT2	11/10/2010 8:2...	3B89D497
NGA_no_1044_NWH-UP.AT2	30,587	9,588	File AT2	11/10/2010 8:2...	F508F88F

(b) Step (3)

Figure 54: Save Scaled and Unscaled Acceleration Time Series Files

5.8.2 PGMD Search Report – Scaled Section

The PGMD search criteria and summary of the selected records can be exported by clicking "Save Search Spectra" button (cf. Figure 55). The horizontal components and the vertical component information will be exported together. A pop-up window allows the user to specify the file name and file type ("csv' or 'txt' format). "cvs" (Comma Separated Variables) file format is preferred since it can be opened using Microsoft Excel, or any text editor.

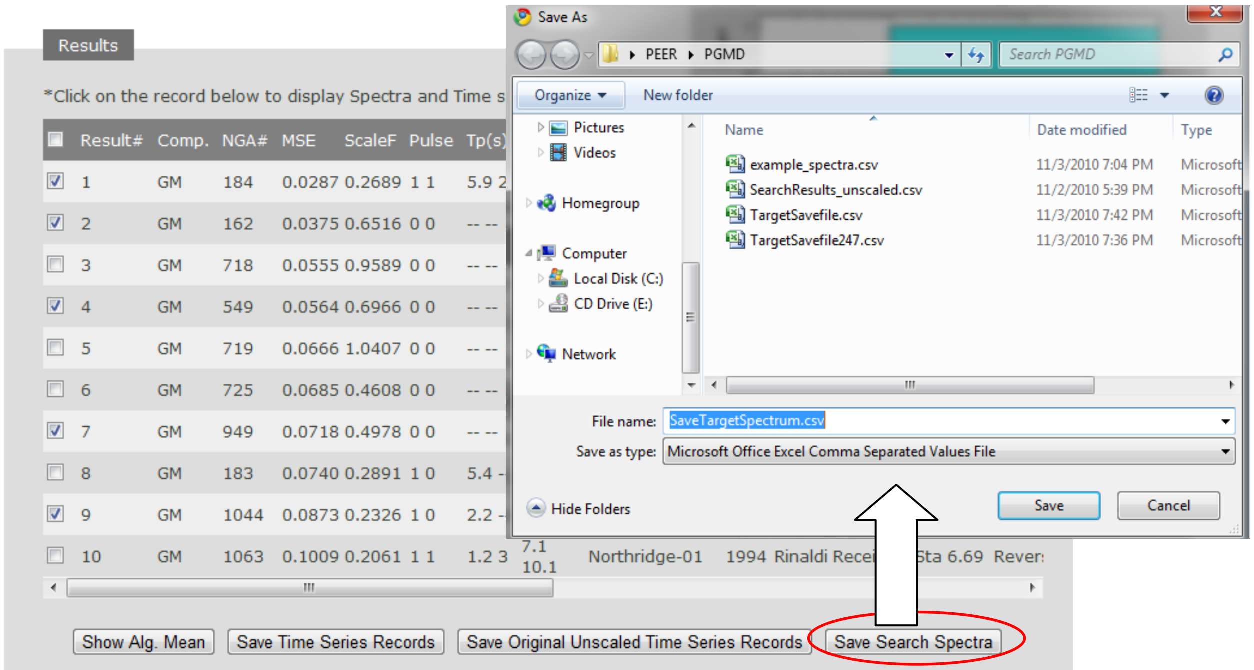
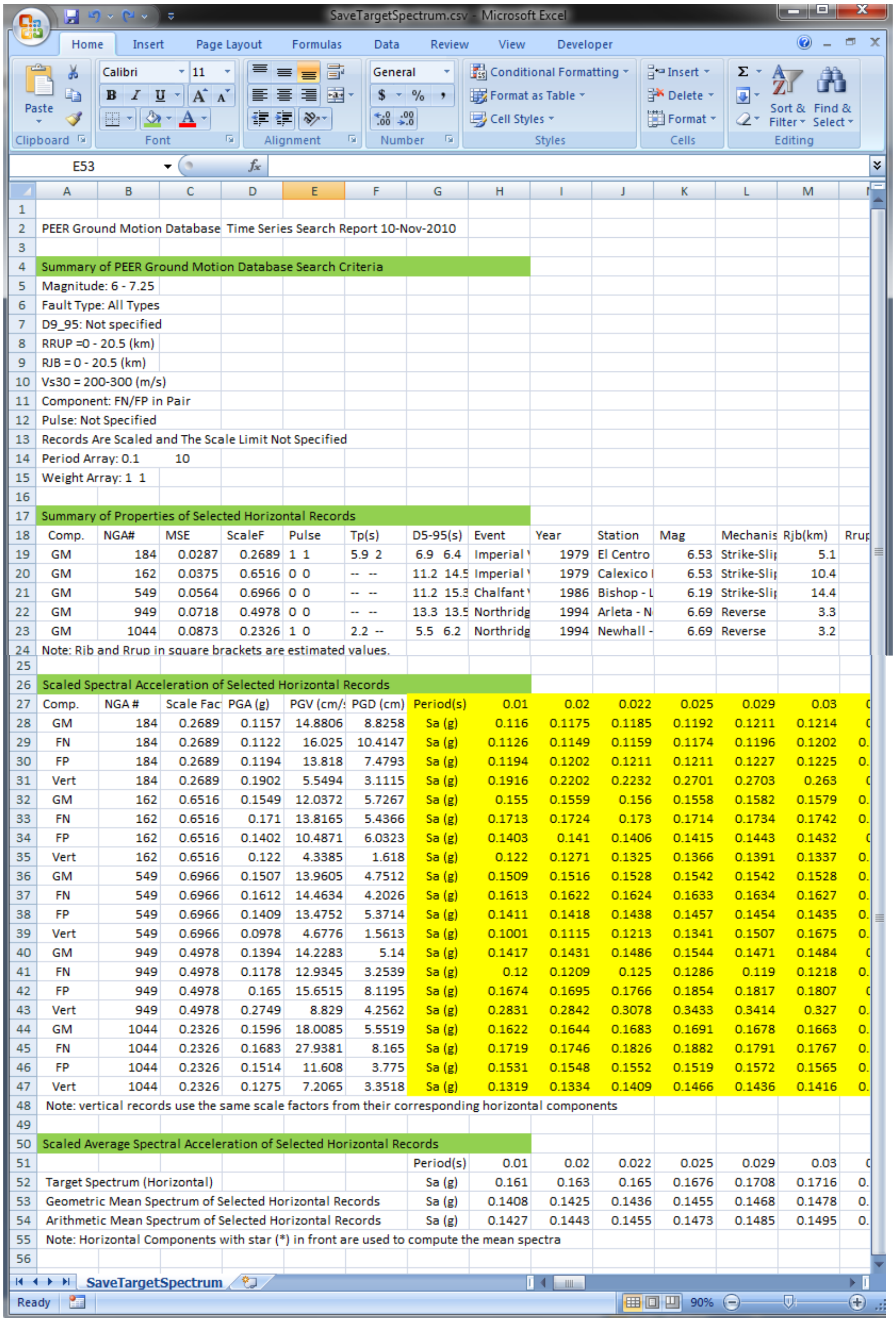


Figure 55: Save PGMD Search Result – Scaled Section



SaveTargetSpectrum.csv - Microsoft Excel

	A–F	G	H	I	J	K	L	M
2	PEER Ground Motion Database Time Series Search Report 10-Nov-2010							
4	Summary of PEER Ground Motion Database Search Criteria							
5	Magnitude: 6 - 7.25							
6	Fault Type: All Types							
7	D9_95: Not specified							
8	RRUP =0 - 20.5 (km)							
9	RJB = 0 - 20.5 (km)							
10	Vs30 = 200-300 (m/s)							
11	Component: FN/FP in Pair							
12	Pulse: Not Specified							
13	Records Are Scaled and The Scale Limit Not Specified							
14	Period Array: 0.1 10							
15	Weight Array: 1 1							
17	Summary of Properties of Selected Horizontal Records							

Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanis	Rjb(km)	Rrup
GM	184	0.0287	0.2689	1 1	5.9 2	6.9 6.4	Imperial	1979	El Centro	6.53	Strike-Slip	5.1	
GM	162	0.0375	0.6516	0 0	-- --	11.2 14.5	Imperial	1979	Calexico	6.53	Strike-Slip	10.4	
GM	549	0.0564	0.6966	0 0	-- --	11.2 15.3	Chalfant	1986	Bishop - L	6.19	Strike-Slip	14.4	
GM	949	0.0718	0.4978	0 0	-- --	13.3 13.5	Northridg	1994	Arleta - N	6.69	Reverse	3.3	
GM	1044	0.0873	0.2326	1 0	2.2 --	5.5 6.2	Northridg	1994	Newhall -	6.69	Reverse	3.2	

Note: Rib and Rrup in square brackets are estimated values.

Scaled Spectral Acceleration of Selected Horizontal Records

Comp.	NGA #	Scale Fac	PGA (g)	PGV (cm/s)	PGD (cm)	Period(s)	0.01	0.02	0.022	0.025	0.029	0.03
GM	184	0.2689	0.1157	14.8806	8.8258	Sa (g)	0.116	0.1175	0.1185	0.1192	0.1211	0.1214
FN	184	0.2689	0.1122	16.025	10.4147	Sa (g)	0.1126	0.1149	0.1159	0.1174	0.1196	0.1202
FP	184	0.2689	0.1194	13.818	7.4793	Sa (g)	0.1194	0.1202	0.1211	0.1211	0.1227	0.1225
Vert	184	0.2689	0.1902	5.5494	3.1115	Sa (g)	0.1916	0.2202	0.2232	0.2701	0.2703	0.263
GM	162	0.6516	0.1549	12.0372	5.7267	Sa (g)	0.155	0.1559	0.156	0.1558	0.1582	0.1579
FN	162	0.6516	0.171	13.8165	5.4366	Sa (g)	0.1713	0.1724	0.173	0.1714	0.1734	0.1742
FP	162	0.6516	0.1402	10.4871	6.0323	Sa (g)	0.1403	0.141	0.1406	0.1415	0.1443	0.1432
Vert	162	0.6516	0.122	4.3385	1.618	Sa (g)	0.122	0.1271	0.1325	0.1366	0.1391	0.1337
GM	549	0.6966	0.1507	13.9605	4.7512	Sa (g)	0.1509	0.1516	0.1528	0.1542	0.1542	0.1528
FN	549	0.6966	0.1612	14.4634	4.2026	Sa (g)	0.1613	0.1622	0.1624	0.1633	0.1634	0.1627
FP	549	0.6966	0.1409	13.4752	5.3714	Sa (g)	0.1411	0.1418	0.1438	0.1457	0.1454	0.1435
Vert	549	0.6966	0.0978	4.6776	1.5613	Sa (g)	0.1001	0.1115	0.1213	0.1341	0.1507	0.1675
GM	949	0.4978	0.1394	14.2283	5.14	Sa (g)	0.1417	0.1431	0.1486	0.1544	0.1471	0.1484
FN	949	0.4978	0.1178	12.9345	3.2539	Sa (g)	0.12	0.1209	0.125	0.1286	0.119	0.1218
FP	949	0.4978	0.165	15.6515	8.1195	Sa (g)	0.1674	0.1695	0.1766	0.1854	0.1817	0.1807
Vert	949	0.4978	0.2749	8.829	4.2562	Sa (g)	0.2831	0.2842	0.3078	0.3433	0.3414	0.327
GM	1044	0.2326	0.1596	18.0085	5.5519	Sa (g)	0.1622	0.1644	0.1683	0.1691	0.1678	0.1663
FN	1044	0.2326	0.1683	27.9381	8.165	Sa (g)	0.1719	0.1746	0.1826	0.1882	0.1791	0.1767
FP	1044	0.2326	0.1514	11.608	3.775	Sa (g)	0.1531	0.1548	0.1552	0.1519	0.1572	0.1565
Vert	1044	0.2326	0.1275	7.2065	3.3518	Sa (g)	0.1319	0.1334	0.1409	0.1466	0.1436	0.1416

Note: vertical records use the same scale factors from their corresponding horizontal components

Scaled Average Spectral Acceleration of Selected Horizontal Records

	Period(s)	0.01	0.02	0.022	0.025	0.029	0.03
Target Spectrum (Horizontal)	Sa (g)	0.161	0.163	0.165	0.1676	0.1708	0.1716
Geometric Mean Spectrum of Selected Horizontal Records	Sa (g)	0.1408	0.1425	0.1436	0.1455	0.1468	0.1478
Arithmetic Mean Spectrum of Selected Horizontal Records	Sa (g)	0.1427	0.1443	0.1455	0.1473	0.1485	0.1495

Note: Horizontal Components with star (*) in front are used to compute the mean spectra

Figure 56: An Example of PGMD Scaled Search Report

Figure 56 illustrates an example of the PGMD scaled search report (named as SaveTargetSpectrum.csv in this case) opened by Microsoft Excel. The search report features the following data blocks:

(1) ***Summary of PGMD search criteria.*** All user-defined search criteria are listed in this data field, including the magnitude range, fault type, specified D9-95 range, specified R_{rup} and R_{jb} ranges, specified V_{S30} range, component specification, pulse characteristics, scale factor limit, period array and weight array.

(2) ***Summary of Properties of Selected Horizontal Records.*** The same information in the PGMD output list window is reported only for selected records (these marked with stars). The reported properties of each selected record are: Component Indicator, NGA number, Mean Squared Error (MSE), Scale Factor, Pulse Indicator, Pulse Periods, D5-95 duration, Event Name, Year, Station Name, Magnitude, Fault Mechanism, R_{JB}, R_{Rup}, V_{S30}, recommended lowest usable frequency, and the acceleration record file names. Please note that if R_{JB} or R_{Rup} is in a squared bracket, it indicates that the value is absent in NGA Flatfile. The reported value was estimated by Chiou and Youngs (2008b).

(3) ***Scaled Spectral Acceleration of Selected Horizontal and Vertical Records***. For each selected record listed in data field (2), their component indicator, NGA number, scale factor, *scaled* PGA, PGV, PGD values and *scaled* spectra acceleration values are reported in this data field. The scaled spectra acceleration values are reported for the following periods (in seconds):

0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.036	0.04
0.042	0.044	0.045	0.046	0.048	0.05	0.055	0.06	0.065	0.067
0.07	0.075	0.08	0.085	0.09	0.095	0.1	0.11	0.12	0.13
0.133	0.14	0.15	0.16	0.17	0.18	0.19	0.2	0.22	0.24
0.25	0.26	0.28	0.29	0.3	0.32	0.34	0.35	0.36	0.38
0.4	0.42	0.44	0.45	0.46	0.48	0.5	0.55	0.6	0.65
0.667	0.7	0.75	0.8	0.85	0.9	0.95	1	1.1	1.2
1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2.5	2.6	2.8	3	3.2	3.4	3.5	3.6	3.8	4
4.2	4.4	4.6	4.8	5	5.5	6	6.5	7	7.5
8	8.5	9	9.5	10					

(4) ***Scaled Average Spectral Acceleration of Selected Horizontal Records***. The data field reports the target spectrum (horizontal) values, and both geometric mean spectrum and arithmetic mean spectrum of selected horizontal records (see definitions of geometric mean and arithmetic mean of spectrum, Section 3.2.1 of Users Manual). Please note that the reported target spectrum is re-interpolated to the same period sequence as used in data field (3), therefore, the values may be slightly different from user's original input.

5.8.3 Save the Plot

Both spectrum and time series plots can be saved to the disk as figure files as described in Section 3.5.3.

6. PGMD EXAMPLES

Examples are provided below to illustrate the major steps in selecting suitable ground motion records using the PGMD. The examples are served mainly for the purpose of demonstration and not for the purpose of any practical application.

6.1 Record Selection and Modification

Step 1. Developing the Target Spectrum

The site selected for the example is Site Class D at a location in San Francisco approximately 10 km from the San Andreas Fault. The structure was assumed to be a medium- to high-rise building having a significant period range of 0.3 to 3 seconds. The design response spectrum is a Code spectrum, and the following steps are needed to construct the spectrum.

(1) ***Go to Scaled Section***: Click Scaled at the PGMD home page.

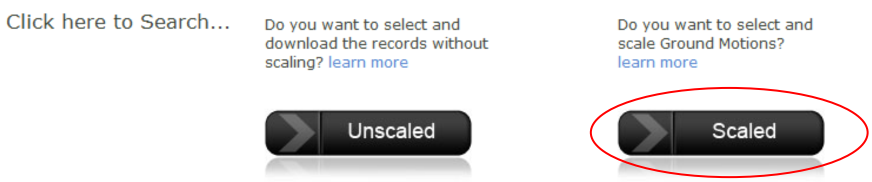


Figure 57: Select Scaled Section

(2) ***Select Spectrum Model***: Choose "ASCE Code Spectrum" from the drop menu.

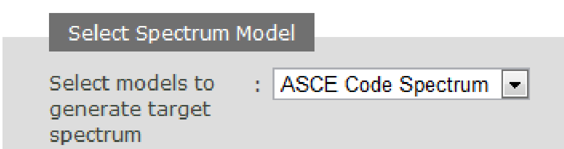


Figure 58: Select Spectrum Model

(3) ***Specify Spectrum Parameters***: By referring to the design ground motion maps and provisions of ASCE standard ASCE/SEI 7-05, parameters Sds, Sd1, and TL needed to construct the code design spectrum are obtained as follows, where equations, figures, maps, and tables refer to ASCE (2006):

Maximum Considered Earthquake parameters:
Ss=1.5g (Map, p. 214), Fa= 1.0 (Table 11.4-1), Sms=1.5g (Eq.11.4-1)
S1=0.75g (Map, p.216), Fv=1.5 (Table 11.4-2), Sm1=1.125g (Eq. 11.4-2)

Design earthquake parameters:
Sds=2/3*Sms=1.0g (Eq. 11.4-3)
Sd1=2/3*Sm1=0.75g (Eq. 11.4-4)
TL=12 sec (Fig. 22-16)

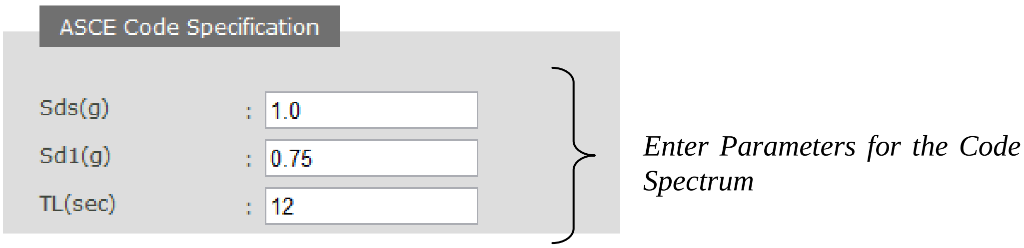


Figure 59: Specify Spectrum Parameters

(4) ***Create the Target Design Spectrum***: Press "Create" button to create the target spectrum, which is shown in the spectrum plot window as follows:

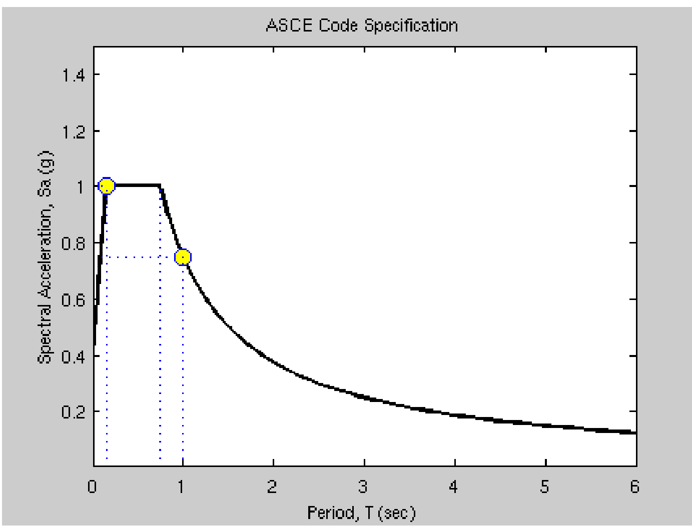


Figure 60: The Target Design Spectrum

Press **NEXT** button to proceed to the next step.

Step 2. Defining the Search Criteria

The USGS web site, http://earthquake.usgs.gov/research/hazmaps, was used to deaggregate the site ground motion hazard. At 1-second period, the dominant contributor to the hazard was an earthquake of approximately magnitude 7.8 occurring on the San Andreas Fault. For purposes of the example, the search was restricted to recordings from strike-slip (SS) earthquakes of magnitude 7 and higher occurring within 30 km of the site. A wide range of V_{S30} limits and no restrictions on significant duration ($D_{5\text{-}95}$) or on scale factor were utilized in order to capture a sufficiently large set of potential records for examination and scaling and matching of recorded spectra to the Code spectrum within the significant period range. It is noted that although specifying the site V_{S30} and site class is essential in developing the design response spectrum, it is not so important in selecting records because the search will rank the records with respect to their match to the design spectrum. It was assumed that matching would be to the Code spectrum rather than to a conditional mean spectrum. Equal weight was given to matching at all periods within the significant period range (0.3-3 sec). No restrictions were placed for searching on whether the record should or should not have pulses. The display of search criteria is shown in Figure 46.

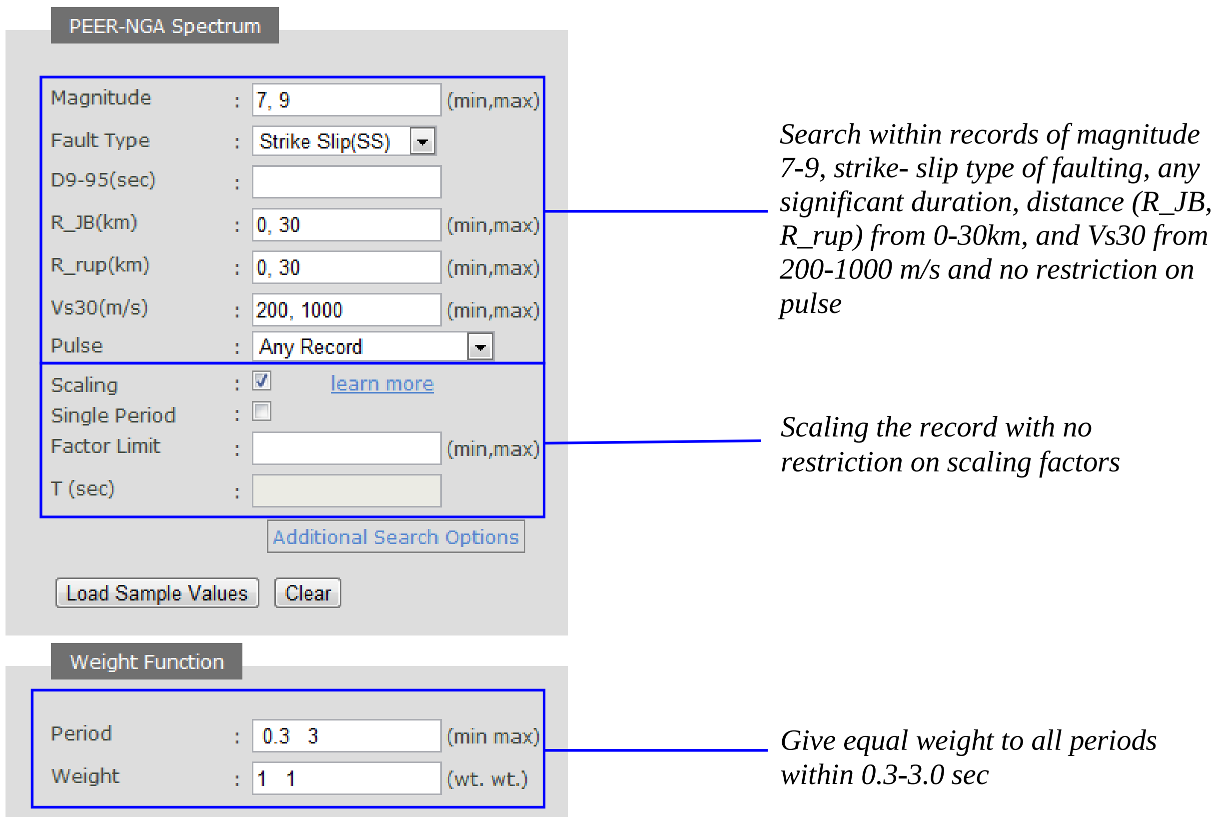
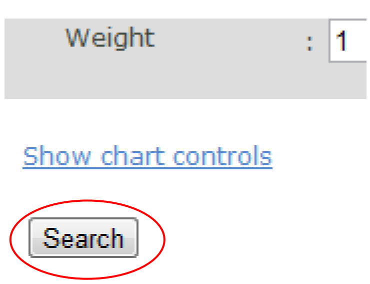


Figure 61: Specify the Search Criteria

Step 3. Searching for Records

Press “Search” button.



Step 4. Inspect, Evaluate, and Finalize the Search Result

As shown in Figure 61, the search was set up to output 30 records and computes the average spectrum for the 7 records that best match the Code spectrum. Although the default is to output 30 records, only 23 results, as shown in Figure 61, matched the criteria given in Figure 60. Clicking on an individual record allows one to examine the spectrum and acceleration/ velocity/ displacement time series of that record.

The best-matching 7 records are called **"Selected Records"**, with their checkbox check for identification. Figure 61 shows the top 7 records (with ✓ symbols) that are selected by PGMD. However, the user has the capability to reject records from or add records to the list of selected records. The next step is to adjust the list of selected records and finalize the search result.

After inspecting the records, it was decided to reject records NGA# 879, NGA# 900, and add records NGA# 1176, NGA# 1613 into the list of selected records. Figure 62 shows the operation to include or exclude an individual record. **Note that the selected records always have ✓ symbol in the front.** The finalized 7 selected records are summarized in Table 4.

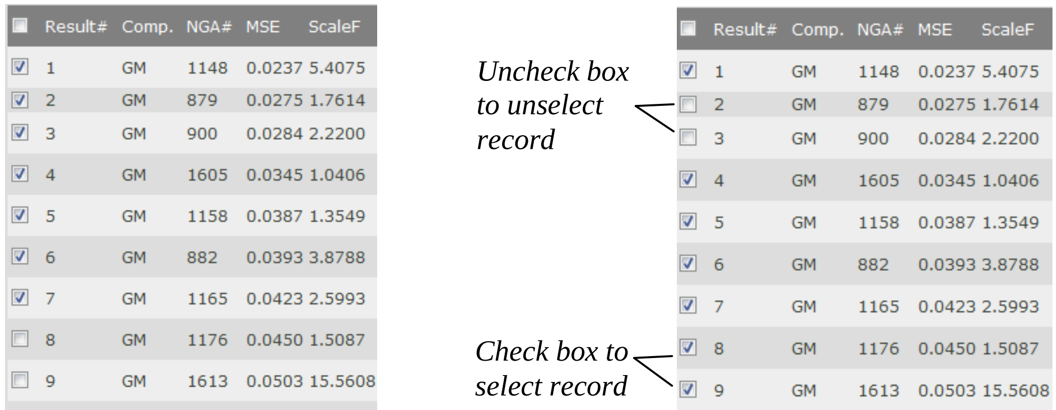
Check to only plot and calculate average of records that have been selected. If Plot Selected box has been previously checked then press the Refresh button.

☐ Plot Selected [Refresh]

Check records to include or exclude from selected list.

☐	Result#	Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanism	Rjb(km)	Rrup(km)	Vs30(m/s)	Lowest useable freq(Hz)	FN Acc. File Name	FP Acc. File Name	Vertical Acc. File Name
☑	1	GM	1148	0.0237	5.4075	0 1	-- 6.7	11.0 10.3	Kocaeli, Turkey	1999	Arcelik	7.51	Strike-Slip	10.6	13.5	523.0	0.09	KOCAELI/ARC_FN.acc	KOCAELI/ARC_FP.acc	KOCAELI/ARCDWN.AT2
☑	2	GM	879	0.0275	1.7614	1 0	5.1 --	0.0 0.0	Landers	1992	Lucerne	7.28	Strike-Slip	2.2	2.2	684.9	0.10	LANDERS/LCN_FN.acc	LANDERS/LCN_FP.acc	LANDERS/LCN-UP.AT2
☑	3	GM	900	0.0284	2.2200	1 0	7.5 --	17.2 19.6	Landers	1992	Yermo Fire Station	7.28	Strike-Slip	23.6	23.6	353.6	0.07	LANDERS/YER_FN.acc	LANDERS/YER_FP.acc	LANDERS/YER-UP.AT2
☑	4	GM	1605	0.0345	1.0406	0 1	-- 5.6	10.9 10.7	Duzce, Turkey	1999	Duzce	7.14	Strike-Slip	0.0	6.6	276.0	0.10	DUZCE/DZC_FN.acc	DUZCE/DZC_FP.acc	DUZCE/DZC-UP.AT2
☑	5	GM	1158	0.0387	1.3549	0 0	-- --	11.7 10.1	Kocaeli, Turkey	1999	Duzce	7.51	Strike-Slip	13.6	15.4	276.0	0.24	KOCAELI/DZC_FN.acc	KOCAELI/DZC_FP.acc	KOCAELI/DZC-UP.AT2
☑	6	GM	882	0.0393	3.8788	0 0	-- --	37.0 36.3	Landers	1992	North Palm Springs	7.28	Strike-Slip	26.8	26.8	345.4	0.28	LANDERS/NPS_FN.acc	LANDERS/NPS_FP.acc	LANDERS/NPS-UP.AT2
☑	7	GM	1165	0.0423	2.5993	0 0	-- --	15.0 13.2	Kocaeli, Turkey	1999	Izmit	7.51	Strike-Slip	3.6	7.2	811.0	0.12	KOCAELI/IZT_FN.acc	KOCAELI/IZT_FP.acc	KOCAELI/IZT-UP.AT2
☐	8	GM	1176	0.0450	1.5087	1 1	4.5 4.6	15.4 14.9	Kocaeli, Turkey	1999	Yarimca	7.51	Strike-Slip	1.4	4.8	297.0	0.09	KOCAELI/YPT_FN.acc	KOCAELI/YPT_FP.acc	KOCAELI/YPT-UP.AT2
☐	9	GM	1613	0.0503	15.5608	0 0	-- --	18.9 12.5	Duzce, Turkey	1999	Lamont 1060	7.14	Strike-Slip	25.8	25.9	782.0	0.07	DUZCE/1060_FN.acc	DUZCE/106_FN.acc	DUZCE/1060-V.AT2
☐	10	GM	880	0.0517	5.8693	0 0	-- --	40.2 34.7	Landers	1992	Mission Creek Fault	7.28	Strike-Slip	27.0	27.0	345.4	0.11	LANDERS/MCF_FN.acc	LANDERS/MCF_FP.acc	LANDERS/MCF-UP.AT2
☐	11	GM	850	0.0584	3.4389	0 0	-- --	32.0 31.8	Landers	1992	Desert Hot Springs	7.28	Strike-Slip	21.8	21.8	345.4	0.07	LANDERS/DSP_FN.acc	LANDERS/DSP_FP.acc	LANDERS/DSP-UP.AT2
☐	12	GM	1616	0.0643	14.4388	0 0	-- --	19.3 20.4	Duzce, Turkey	1999	Lamont 362	7.14	Strike-Slip	23.4	23.4	517.0	0.07	DUZCE/362_FN.acc	DUZCE/362_FP.acc	DUZCE/362-V.AT2
☐	13	GM	864	0.0650	1.7399	0 0	-- --	26.0 27.2	Landers	1992	Joshua Tree	7.28	Strike-Slip	11.0	11.0	379.3	0.07	LANDERS/JOS_FN.acc	LANDERS/JOS_FP.acc	LANDERS/JOS-UP.AT2
☐	14	GM	1611	0.0792	6.4949	0 0	-- --	14.2 15.2	Duzce, Turkey	1999	Lamont 1058	7.14	Strike-Slip	0.2	0.2	424.8	0.07	DUZCE/1058_FN.acc	DUZCE/105_FN.acc	DUZCE/1058-V.AT2
☐	15	GM	881	0.1065	2.7705	0 0	-- --	32.1 31.0	Landers	1992	Morongo Valley	7.28	Strike-Slip	17.3	17.3	345.4	0.28	LANDERS/MVH_FN.acc	LANDERS/MVH_FP.acc	LANDERS/MVH-UP.AT2
☐	16	GM	1787	0.1069	1.9288	0 0	-- --	9.7 11.2	Hector Mine	1999	Hector	7.13	Strike-Slip	10.3	11.7	684.9	0.04	HECTOR/HEC_FN.acc	HECTOR/HEC_FP.acc	HECTOR/HECVER.AT2
☐	17	GM	1602	0.1307	1.0352	0 1	-- 0.91	8.5 9.9	Duzce, Turkey	1999	Bolu	7.14	Strike-Slip	12.0	12.0	326.0	0.06	DUZCE/BOL_FN.acc	DUZCE/BOL_FP.acc	DUZCE/BOL-UP.AT2
☐	18	GM	2114	0.1428	1.1253	0 1	-- 5.7	25.4 22.4	Denali, Alaska	2002	TAPS Pump Station #10	7.90	Strike-Slip	0.2	2.7	329.4	0.03	DENALI/ps10_FN.acc	DENALI/ps10_FP.acc	DENALI/ps10-UP.AT2
☐	19	GM	1614	0.2761	6.7186	0 0	-- --	15.3 12.5	Duzce, Turkey	1999	Lamont 1061	7.14	Strike-Slip	11.5	11.5	481.0	0.09	DUZCE/1061_FN.acc	DUZCE/106_FN.acc	DUZCE/1061-V.AT2
☐	20	GM	1612	0.2790	8.6936	0 0	-- --	14.1 15.2	Duzce, Turkey	1999	Lamont 1059	7.14	Strike-Slip	4.2	4.2	424.8	0.07	DUZCE/1059_FN.acc	DUZCE/105_FN.acc	DUZCE/1059-V.AT2
☐	21	GM	1615	0.2816	4.9099	0 0	-- --	16.1 12.5	Duzce, Turkey	1999	Lamont 1062	7.14	Strike-Slip	9.2	9.2	338.0	0.06	DUZCE/1062_FN.acc	DUZCE/106_FN.acc	DUZCE/1062-V.AT2
☐	22	GM	1618	0.3776	6.0254	0 0	-- --	14.5 15.1	Duzce, Turkey	1999	Lamont 531	7.14	Strike-Slip	8.0	8.0	659.6	0.07	DUZCE/531_FN.acc	DUZCE/531_FP.acc	DUZCE/531-V.AT2
☐	23	GM	1617	0.9309	3.7567	0 0	-- --	12.9 13.6	Duzce, Turkey	1999	Lamont 375	7.14	Strike-Slip	3.9	3.9	424.8	0.19	DUZCE/375_FN.acc	DUZCE/375_FP.acc	DUZCE/375-V.AT2

Figure 62: PGMD Search Result



(a) Default Selection (b) Records Selected by User

Figure 63: Modify the List of Selected Records and Re-average

Table 6. Selected Ground Motion Records

Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanism	Rjb (km)	Rrup (km)	Vs30(m/s)	Low.freq (Hz)
GM	1148	0.0237	5.4075	0 1	-- 6.7	11.0 10.3	Kocaeli-Turkey	1999	Arcelik	7.51	Strike-Slip	10.6	13.5	523	0.09
GM	1605	0.0345	1.0406	0 1	-- 5.6	10.9 10.7	Duzce-Turkey	1999	Duzce	7.14	Strike-Slip	0	6.6	276	0.1
GM	1158	0.0387	1.3549	0 0	-- --	11.7 10.1	Kocaeli-Turkey	1999	Duzce	7.51	Strike-Slip	13.6	15.4	276	0.24
GM	882	0.0393	3.8788	0 0	-- --	37.0 36.3	Landers	1992	North Palm Springs	7.28	Strike-Slip	26.8	26.8	345.4	0.28
GM	1165	0.0423	2.5993	0 0	-- --	15.0 13.2	Kocaeli-Turkey	1999	Izmit	7.51	Strike-Slip	3.6	7.2	811	0.12
GM	1176	0.045	1.5087	1 1	4.5 4.6	15.4 14.9	Kocaeli-Turkey	1999	Yarimca	7.51	Strike-Slip	1.4	4.8	297	0.09
GM	1613	0.0503	15.5608	0 0	-- --	18.9 12.5	Duzce-Turkey	1999	Lamont 1060	7.14	Strike-Slip	25.8	25.9	782	0.07

For the seven selected records, significant duration (5 to 95% of Arias Intensity) ranged from 11 to 37 seconds with an average of about 25 seconds. The average is very close to the median value of about 27 seconds for a magnitude 7.8 earthquake at 10km distance based on the correlation of Kempton and Stewart (2006) in Table 1 of the technical report. Two pulse records are included in the data set, with estimated pulse periods in the range of 4.5 to 5.6 seconds. Although pulse periods of these amplitudes are reasonable for a large-magnitude earthquake (see Figure 9 of the report), it could be desirable to have a record set with a wider range of pulse periods, or a larger number of pulse records, depending on the structural characteristics and response. The average spectrum for the seven selected records is shown in Figure 63, and the background shows the spectra of all 30 listed records. The averaged spectrum has a close match to the target spectrum in the significant period range of 0.3 to 3 sec. The acceleration, velocity, and displacement time series of the selected records are shown in Figure 64.

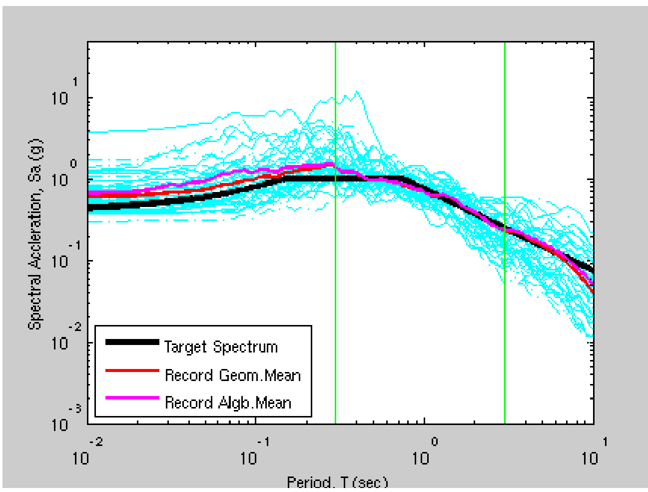
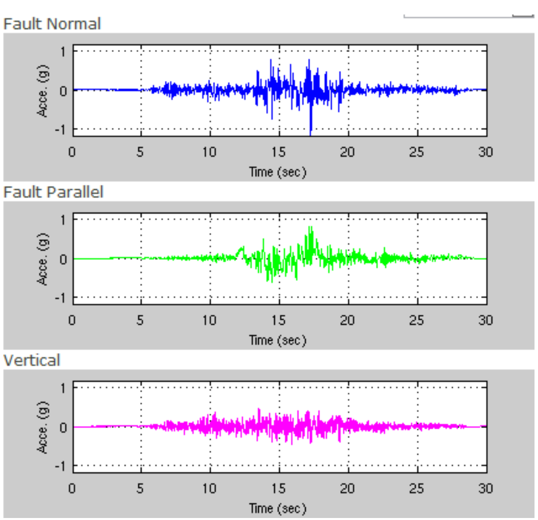
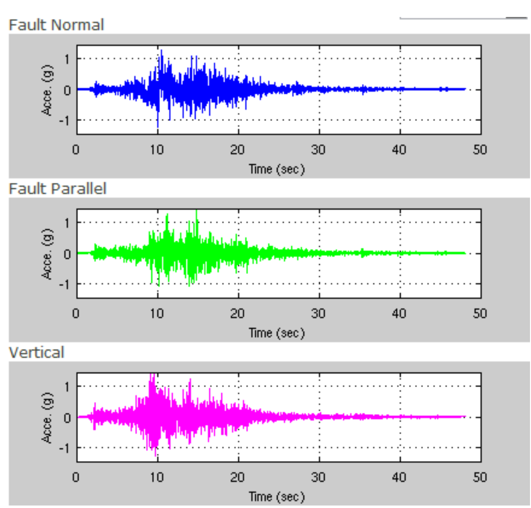


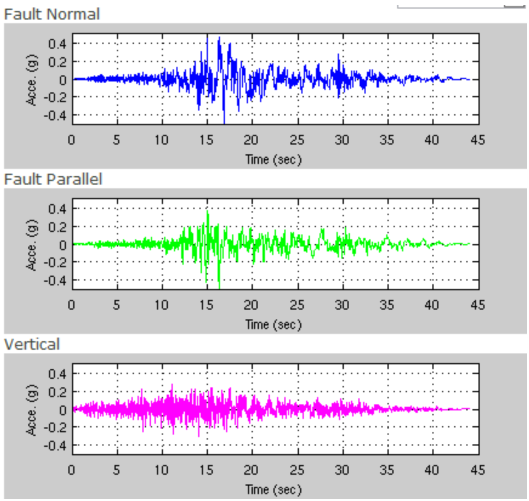
Figure 64: Average Spectrum of 7 Selected Records



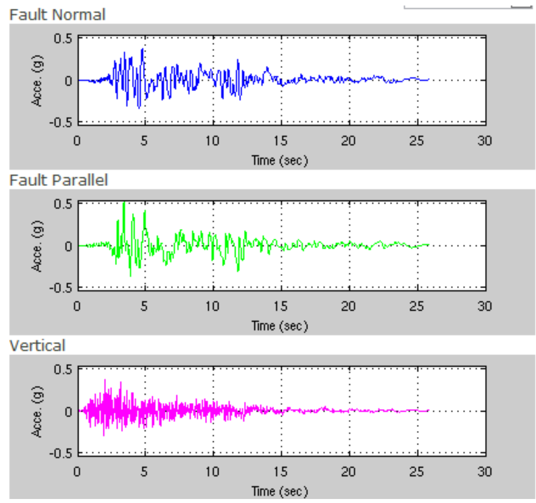
Record # 1148



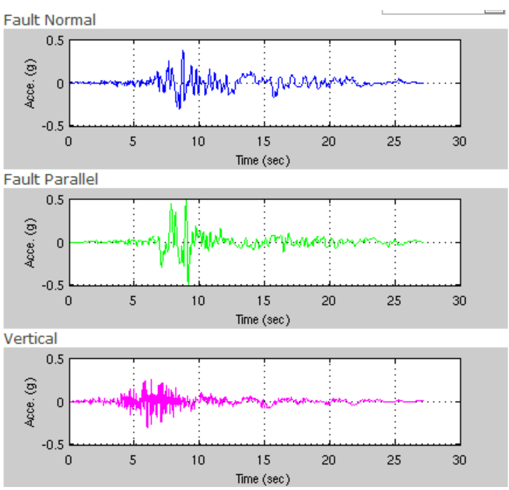
Record # 879



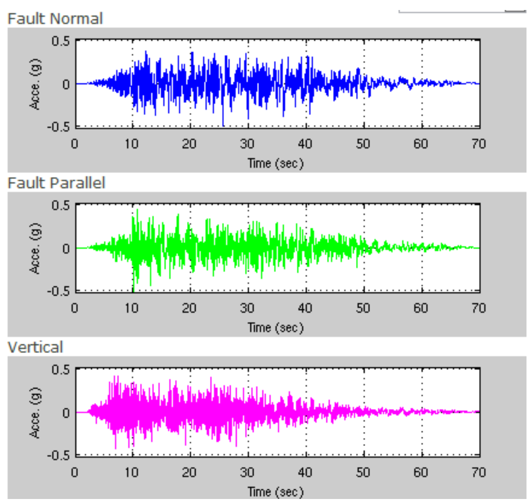
Record # 900



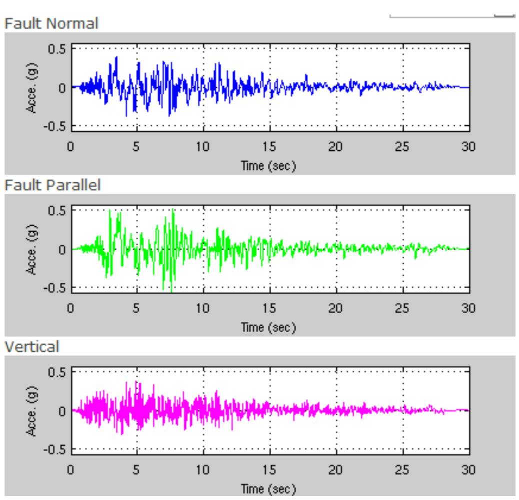
Record # 1605



Record # 1158



Record # 882



Record # 1165

Figure 65: The Acceleration, Velocity and Displacement Time Series of Selected Records

6.2 USE PGMD SUPPLEMENTARY SEARCH ENGINE

The previous example illustrates the steps to use PGMD's default search engine to select and modify ground motion records. In the scaled section, a supplementary search engine is provided to enhance the search capability, which is documented in Section 5.3 of this manual. The supplementary search engine is useful to inspect the properties of a set of records according to specified sequence of NGA numbers, and/or event name, station name.

Step 1. Switch to Supplementary Search Engine

Press "Additional Search Options" button to activate the Supplementary Search Engine. The user interface is shown in Figure 65.

Step 2. Search According to NGA Numbers

The final result from Example 5.1 can be easily reproduced using the Supplementary Search Engine. First, specify the NGA sequence numbers with the rule set in Section 5.3. The "Pulse" and other options also need to be set properly as shown in the Figure 65.

After pressing the "Search" button, only the specified seven records are displayed. The spectrum plots are shown in Figure 66, where the target spectrum, the average spectrum and each of the selected records are illustrated in colors. Please also notice the difference between Figure 66 with Figure 63, where the background in Figure 63 shows the spectra of all 30 listed records.

Step 3. Search According to Event Name

Assuming that the user particularly wants to include records from Northridge earthquake. one can use the Supplementary Search Engine to search records according to the "Event Name", as shown in Figure 53. All records with "Event Name" containing the key word "Northridge-01" will be searched and displayed.

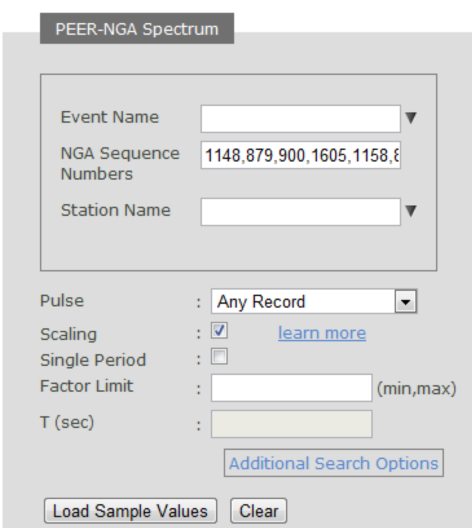


Figure 66: Search by NGA Sequence Using the Supplementary Search Engine

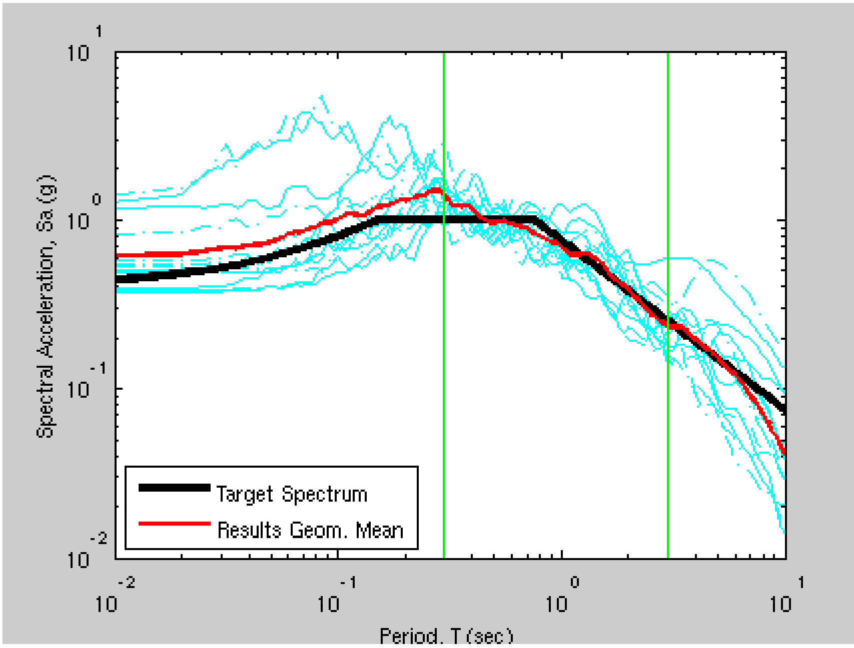


Figure 67: Plot Spectra of Selected 7 Records

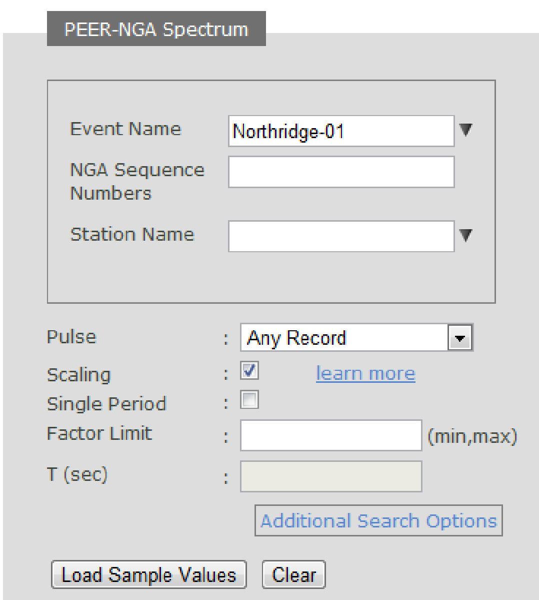


Figure 68: Search by Event Name Using the Supplementary Search Engine

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