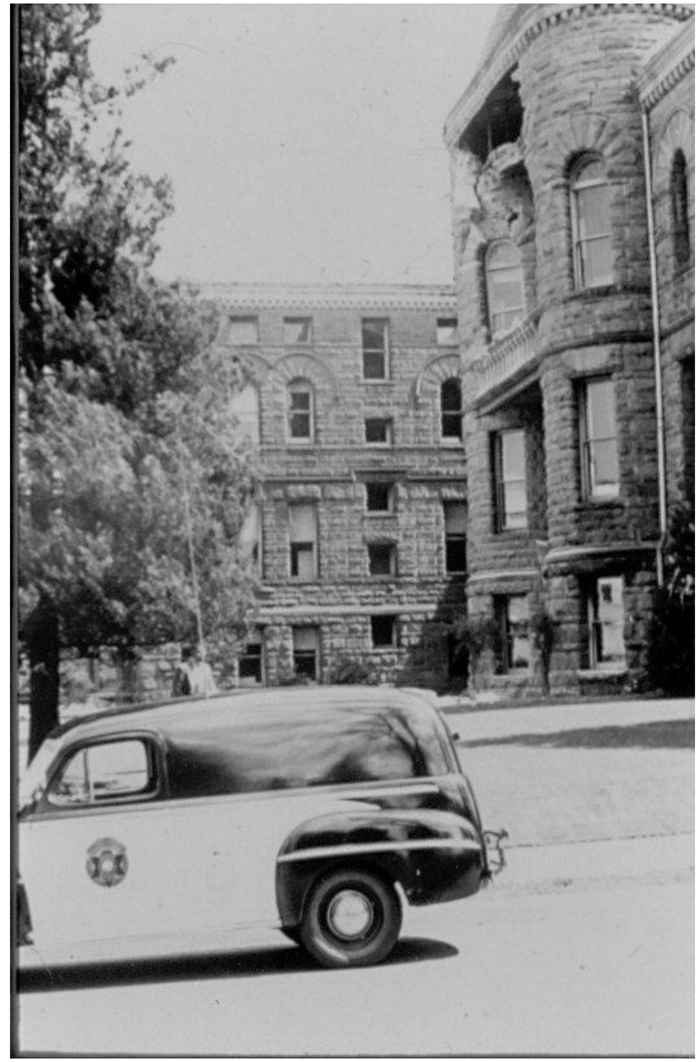
Location 1c. Damage to “old state capitol bulding” in the April 13, 1949 earthquake. Photo supplied by Jim Sims.



Location 1d. Damage to “old state capitol bulding” in the April 13, 1949 earthquake. Photo supplied by Jim Sims.

Location 2. Parapet failure in 1949 earthquake, collapsing awning. Although the earthquake occurred at midday on a sunny Wednesday, no one was injured here. Photo by Roger Easton.

Location 3. Cracking in the wall of the old Capitol Theatre**.** Photo supplied by Jim Sims.

Location 4a. Masonry damage to the Hotel Olympian building in the 2001 Nisqually earthquake. Photo by Josh Logan.

Location 4b. Masonry damage to the Hotel Olympian building in the 2001 Nisqually earthquake. Photo by Josh Logan.

Location 5a. Parapet and awning failure at M. M. Morris, now occupied by Wind Up Here. Photo supplied by Jim Sims.

Location 5b Closeup of 5a. Photo supplied by Jim Sims

Location 6. Seattle First National bank, now Precious Metalsmith. Photo supplied by Jim Sims.

Location 7a. Damage to the Washington Federal Savings building. (now occupied by Reflections Gallery. Photo by Josh Logan.

Location 7b. Washington Federal Savings. Photo by Josh Logan.

Location 7c. Washington Federal Savings. Photo by Joe Dragovich.

Location 8a. Damage to Skookum Bay outfitters, now Batdorf and Bronson Coffee Roasters and, until recently, Cielo Blu. This extensive damage bankrupted the business. Photo by Josh Logan.

Location 8b. Closeup of 8a. Skookum BayOutfitters owned this building but did not have earthquake insurance and was unable to get an SBA loan**.** Photo by Josh Logan.

Location 9. Formerly the Miller Building, now occupied by Starbucks. Photo supplied by Jim Sims

Location 10. New Governor Hotel. This location is now the Governor Hotel, after extensive rebuilding/remodeling Photo supplied by Jim Sims.

Posted on Tue, Feb. 05, 2008

San Simeon Quake Trial: Victims' families awarded $2 million

Leah Etling

A jury recommended nearly $2 million in damages Monday for the families of two women killed in the collapse of a building in the 2003 San Simeon Earthquake, saying the building's owner was negligent in not reinforcing it. The verdict in the civil wrongful-death trial included $600,000 each for the parents of Jennifer Myrick, $600,000 for the daughter of Marilyn Frost-Zafuto and $100,000 for Frost-Zafuto's husband.

Myrick, 20, and Frost-Zafuto, 55, died while trying to flee the historic Acorn Building in downtown Paso Robles during the magnitude-6.5 quake.

In finding for the plaintiffs, the jury decided property owner Mary Mastagni and several trusts and businesses owned by her family were responsible for the 111-year-old Acorn Building and negligent in its maintenance and operation. The jury also decided that Mastagni, 84, violated state law by not placing a sign on the unreinforced masonry building that warned people it could be dangerous in case of an earthquake. However, it also said that violation was not a factor in the women's deaths.

The plaintiffs included Myrick's parents, Leroy and Vicky Myrick of Idaho; Dennis Zafuto of Paso Robles, widower of Frost-Zafuto; and Allison Frost Phillips of Texas, Frost-Zafuto's daughter. All of the plaintiffs attended nearly all of the two-month trial. And all expressed satisfaction with the outcome.

"It won't ever bring my mother back or Jen; it won't ever close that door for us," Phillips said. "But the jurors have spoken, and there is accountability. That does give us the closure we were looking for."

Dennis Zafuto said the amount of money was not an issue to him, and he felt justice was served. "The price on someone's life is impossible to determine," he said.

The Myricks said they hope the verdict will set an example for other owners of unreinforced buildings. The couple has worked to tighten legislation regarding such structures.

"This has nothing to do with money," Leroy Myrick said. "They could have given us $50 million, and it could never replace our daughter."

Mastagni and her son, Mark Mastagni, said they had no comment on the verdict. Mary Mastagni attended the trial intermittently because of health issues. Her three children, Mark, Karen Horzen and Sandra Keller, were present each day.

The jury determined that each of the entities named in the multiple lawsuits — Mary Mastagni, the Mastagni Living Trust, the Mastagni Survivors Trust, the Mastagni Children's Trust I and the Mastagni Family LLC — shared responsibility for the women's deaths.

Under state and local laws at the time, the Mastagnis had until 2018 to renovate the building for seismic safety — according to a juror, that fact came up frequently during their discussions.

Mastagni attorney Bob Kaufman said the family will consider whether to appeal. Kaufman didn't find the damages excessive, he said, "given the evidence that was allowed in that we thought shouldn't have been." He declined to specify what evidence that was. He also declined to specify issues on which an appeal might be based.

In a related lawsuit that was tried concurrently, the jury awarded more than $41,000 in damages to Mike and Karen Arrambide, who owned the House of Bread shop in the Acorn Building. They sought damages for the loss of their business and for injuries Karen Arrambide suf fered in the quake.

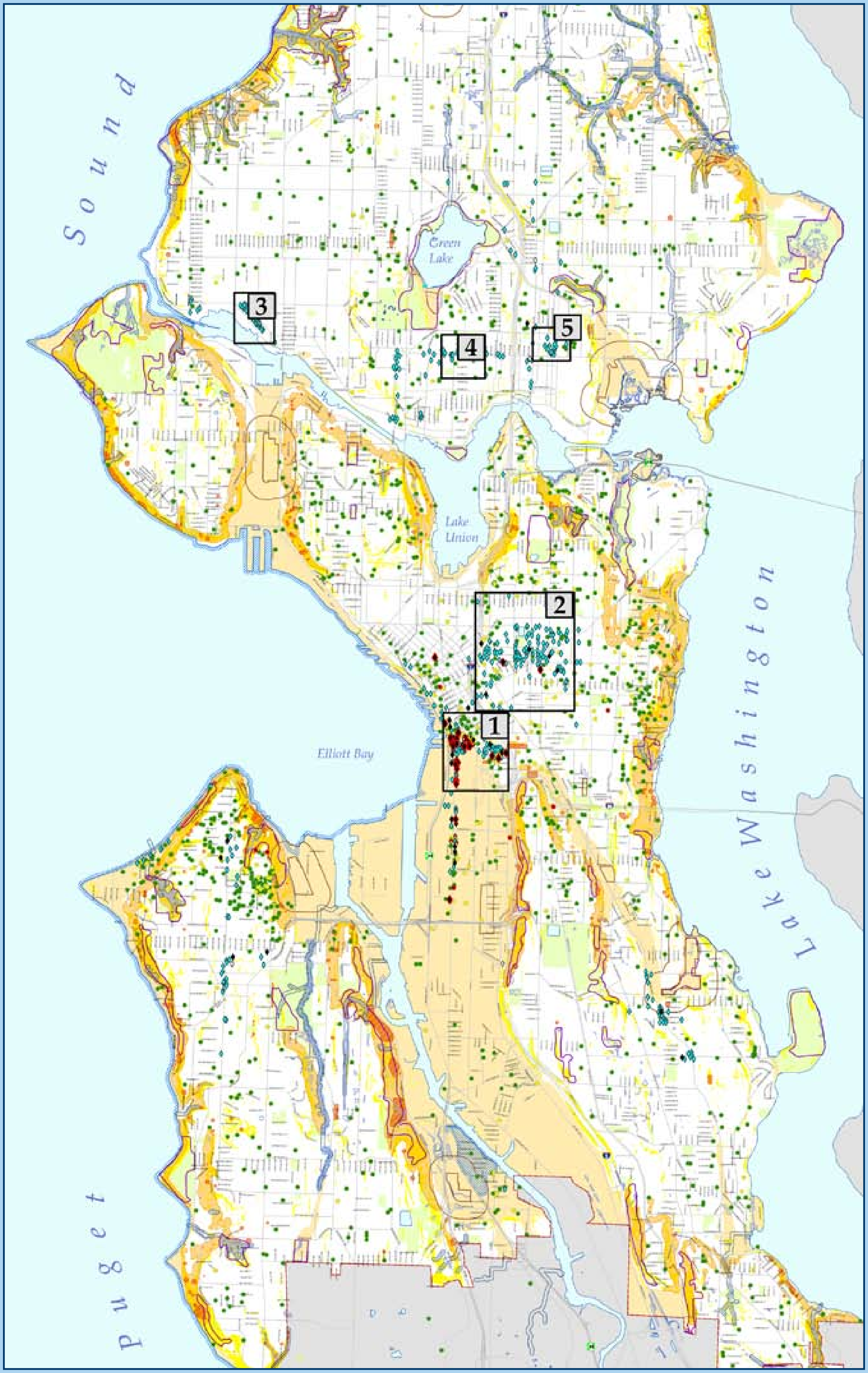
Difficult deliberations

The five-man, seven-woman jury delivered a verdict after one week of deliberations in the courtroom of Judge Teresa Estrada-Mullaney in San Luis Obispo Superior Court. Because it was a civil case, the jury did not have to be unanimous on each decision but had to have at least nine members in favor or opposed to each item. Because of the number of cases combined, the jurors had four special verdict forms to return and dozens of questions to answer. Juror Kelly Fontes of San Luis Obispo said the jurors were glad to be finished with the case; many of them were away from their jobs for three months.

Deliberations were not easy, Fontes said. "There were 12 of us with very different opinions," she said, "and at times, it did get a little heated." Some of the verdict items required compromise, she said, including the amount of damages awarded. "I personally would have liked to see a little more money given to the two families that suf fered losses," she said.

Plaintiffs' attorney Rick Friedman said he also would have liked to see higher damages but felt that the jury made a decision that could be pivotal in whether owners can insure unreinforced masonry buildings. Under current practices, such buildings can be insured easily without being retrofitted. While thanking the jury for its service, Estrada-Mullaney said that there are few jury trials in the county that last as long as this one did. Jury selection began in mid-November.

Tribune staff writer Nick Wilson contributed to this report.



City of Seattle

Unreinforced Masonry Building Seismic Hazards Study

December 2007

Prepared for:

City of Seattle Department of Planning and Develpoment

ReidMiddleton

RMI Project ID# 262007.025

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Executive Summary

Historically, unretrofitted Unreinforced Masonry (URM) buildings have performed poorly during earthquakes. Of the 31 buildings that were posted with red placards indicating the building was considered unsafe for the public to enter, 20 were URM buildings. Of the over $200 million in estimated damage to Seattle resulting from the 2001 Nisqually earthquake, URM buildings appeared to suffer over $8 million in property damage repairs (in terms of 2001 dollars). Furthermore, approximately one out of eight buildings screened had permit records indicating the building sustained damage from the earthquake.

In consolidating previous reports and conducting additional field surveys, a low estimate for the number of URM buildings in Seattle appears to range from 850 to 1000 buildings. There are significant concentrations of URM buildings in areas that are expected to be subjected to the highest seismic forces Seattle is predicted to endure. Also, the City's URM buildings are in significant concentrations throughout the City, extending from the Roosevelt District in the north to Columbia City and West Seattle in the south and west.

In an effort to estimate the cost of future earthquakes, the direct property damage costs from the Nisqually earthquake were used. Note that the design level earthquake and rupturing of the Seattle Fault may cause two to three times the ground motion of the Nisqually earthquake, resulting in markedly increased costs. For financial costs associated with businesses' inability to operate and costs resulting from casualties, a study investigating a Magnitude 6.7 earthquake resulting from the Seattle Fault was referenced. In terms of 2007 dollars, the estimated financial impact has an approximate range of $53 to $91 million.

Based on Seattle's permit records from 1990 to 2007 for the surveyed buildings, the rate of retrofits to URM buildings appears to be below 10 percent. The demolition rate of URM buildings also appears to be below 10 percent. Hence, it appears Seattle's URM buildings may be in a similar condition in 2007 as they were prior to the 2001 Nisqually earthquake.

In an attempt to roughly estimate the cost of seismically retrofitting Seattle's URM buildings to a performance level at which the building may suffer damage but is expected to withstand a design level earthquake without significant damage to the gravity system and without emergency egress being impaired, the Federal Emergency Management Agency's publications were referenced. In terms of 2007 dollars, the estimated structural-only upgrade costs appear to range from $358 to $431 million, with architectural and nonstructural costs (excluding historic preservation and disabled access costs) being approximately 2.5 times higher.

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1.0 Introduction

1.1 Background

On February 28, 2001, the City of Seattle (City) experienced the Nisqually earthquake. Several unreinforced masonry (URM) buildings within the city limits sustained damage during the earthquake, resulting in over $8 million in repair costs. Of the 31 buildings posted with red tags indicating they were considered unsafe and illegal to enter, 20 were URM buildings. Due to the potential risk to the public due to URM buildings during earthquakes, the Seattle City Council has expressed concern about better knowing the extent of risk posed by the City's URM buildings.

Seattle resides in an area of high seismic activity. Although the Nisqually earthquake caused over $200 million in estimated losses to the City (Yamatsuka and Siu, 2002), it is not the largest earthquake the City may experience. Estimates of a Seattle Fault earthquake predict two to three times the maximum ground acceleration as compared to the Nisqually earthquake (Yamatsuka and Siu, 2002), likely causing significantly more damage.

1.2 Purpose

The overall goal of this study is to provide consolidated and updated technical information to the City's Department of Planning and Development (DPD) to help investigate and evaluate appropriate policy level mitigation strategies to reduce the seismic risk posed by URM buildings.

1.3 Scope of Services

The scope of work for this study is limited to providing information to the DPD relating to a sample set of the URM building inventory within the City. The following is a summary of performed work:

1. Consolidated data from previous URM building studies, including the 1994 Cindy Hoover study for DPD, the 1995 EQE City Facility Study, and the 2001 Reid Middleton rapid visual screening work for the DPD after the Nisqually earthquake.
2. Conducted additional field surveys in West Seattle, Capitol Hill, Northgate, Bitter Lake, Downtown, University District (U-District), and Roosevelt District neighborhoods to obtain more data on the City's URM building inventory.
3. Identified, through City records, which URM buildings had been damaged by the 2001 Nisqually earthquake and which buildings had been seismically retrofitted since 1980.
4. Assessed the performance of seismically retrofitted URM buildings during the Nisqually earthquake versus those that were not retrofitted, based on City records.
5. Reviewed City records regarding damaged URM buildings to identify patterns of damage.

1.4 Criteria Used to Identify URM Buildings

URM buildings were identified in the field by common characteristics, such as header bricks, brick sills, brick arches, and wall anchors, as shown in Figure 1. Buildings with these features and constructed before 1940 were included in the URM survey. Typically, West Coast building codes prohibited unreinforced masonry building construction after 1940. The year of the building's construction was usually identified through King County's GIS parcel viewer system, which lists tax records and other information about the structure. In some cases, the year was found through the date indicated on the building's cornerstone or through news articles.

Figure 1. Typical Characteristics of a URM Building.

2.0 Observations

2.1 Sampling of URM Buildings in Seattle

In order to attempt to mitigate risk, a sense of the hazard and vulnerability to that hazard needs to be assessed. Managing seismic risk is no different. To reduce the risk posed by a type of building that performs poorly in earthquakes, i.e., a URM building, the extent of risk should be known. This report has attempted to estimate the number of URM buildings throughout the City, identify where the concentrations of URM buildings occur, and compare these locations to the areas within the City that are expected to receive the strongest earthquake ground motions.

2.1.1 Previous URM Building Surveys

The City has performed or commissioned four significant studies since 1990, collectively noting 575 URM buildings within the City limits. These include the 1994 work by Cynthia Hoover, the 1995 City of Seattle Seismic Hazard Program Summary Report by EQE International, and the 2001 rapid visual screening work per FEMA 154 that Reid Middleton performed for the City after the Nisqually earthquake. The number of URM buildings recorded for each study is indicated in Table 2-1.

Table 2-1. Surveyed URM Buildings since 1990.

Study	Number of Surveyed URM Buildings
1994 Cynthia Hoover Study	132
1995 EQE Study	5
2001 Post Nisqually Study	186
2007 Study	252
Total	575

The Cynthia Hoover study was done by City of Seattle staff using the Applied Technology Council (ATC-21) forms, which have subsequently been adopted by FEMA into FEMA 154 forms. These forms standardize the way an evaluator assesses a building using the outside features of the building. From the assessment, a seismic hazard score may be calculated relatively quickly and assigned to the building. The lower the score, the more likely the building will be damaged during a seismic event. The study had the City inspectors screen all types of buildings, ranging from steel to concrete to unreinforced masonry buildings, in the Lake City, First Hill, Wallingford, and Columbia City areas of Seattle. Of the buildings screened during this work, 132 buildings were noted as URM buildings.

The EQE study examined 78 municipal facilities throughout the city, ranging from single-story fire stations to multi-story office buildings, with a goal to better assess structural and nonstructural hazards. Of the buildings surveyed, five were URM buildings.

The 2001 work performed by Reid Middleton for the City of Seattle in response to the Nisqually earthquake included rapid screening, using ATC forms, of buildings in the Ballard, Pioneer

Square, and International District. Of the buildings Reid Middleton screened after the Nisqually earthquake, 186 were URM buildings.

2.1.2 Estimated Number of URM Buildings Citywide

In order to estimate the extent of the seismic risk posed by URM buildings within the City limits, this report incorporates work from past studies and additional field work, noting the areas surveyed and estimating the number of URM buildings in the areas not surveyed. For the areas of Seattle surveyed, the number of URM buildings in this and previous studies totals 575 buildings. For the areas of Seattle that were not surveyed, two densities of URM buildings per area were used to estimate the likely number of URM buildings. Both were taken from areas that showed the least number of URMs during the survey. These areas were the Northgate/Bitter Lake and Lake City neighborhoods, with estimated densities of approximately 3.8 and 4.6 URM buildings per square mile, respectfully. Out of the approximately 83 square miles of land area for the City of Seattle, a total of approximately 8.3 square miles has been surveyed in this and past studies, and about 1.2 square miles has been identified as park land. The resulting estimated number of buildings that were not surveyed in the remaining areas ranges from 280 to 340. Thus, for a low estimate, the total number of URM buildings likely to be within the City limits ranges from 850 to about 1000 buildings.

2.1.3 Concentration of URM Buildings

Most of Seattle's URM buildings appear to be concentrated in areas that are expected to be subjected to the highest forces during earthquakes. From this and previous studies, there appears to be significant concentrations of URM buildings in the Pioneer Square District, International District, South of the Downtown (SoDo) area, and the Capitol Hill neighborhood. Figure 2 shows that these areas are expected to experience some of the highest seismic forces during an earthquake. Likewise, Figure 3 indicates these areas were subjected to some of the highest earthquake intensities and experienced some of the highest degrees of damage resulting from the 2001 Nisqually earthquake. Hence, URM buildings are in areas that have had and are expected to experience higher impacts from earthquakes.

2.2 Earthquake Considerations of the City's URM Buildings

Unretrofitted URM buildings historically perform poorly during earthquakes, and the 2001 Nisqually earthquake was no exception. DPD's permit history records indicate the City's URM buildings sustained over $8 million in damage.

Also based on the DPD's permit history records, the City of Seattle appears to have low demolition and upgrade rates, especially when compared to other cities such as Oakland or Berkeley, California, which have seen substantial seismic improvements made to their URM buildings. Thus, the situation with the City's URM buildings appears to be much the same in 2007 as it was before the Nisqually earthquake.

2.2.1 URM Building Performance during the 2001 Nisqually Earthquake

Following the 2001 Nisqually earthquake, URM buildings comprised 20 of the 31 buildings that were posted with a red placard indicating the building was considered unsafe to enter. In addition, 74 of the 575, or approximately one out of every eight, URM buildings observed in studies dating from 1990 were noted in the DPD's permit records as being damaged. Figure 4 compares those buildings (of all types) that were red tagged to the URM buildings that were included in this survey. Of the buildings observed since 1990 and that had some sort of permit history in the City's database, 36 of the 74 buildings damaged, or about 48 percent, were listed as hazardous. This hazardous note on the DPD records usually indicates the building was considered hazardous in the view of a City inspector and posted by the inspector as unsafe to enter or with limited entry. Subsequently, the inspector would open a case number for the building for tracking and administrative purposes. However, in a number of instances this note was used in the record without corresponding verbiage indicating posting had occurred. For example, 109 Yesler Way, Case Number 210827, was shown on the permit records as being hazardous after the Nisqually earthquake, but without indication of the building being posted unsafe or given other restrictions.

2.2.2 Estimated Rate of Demolition of URM Buildings

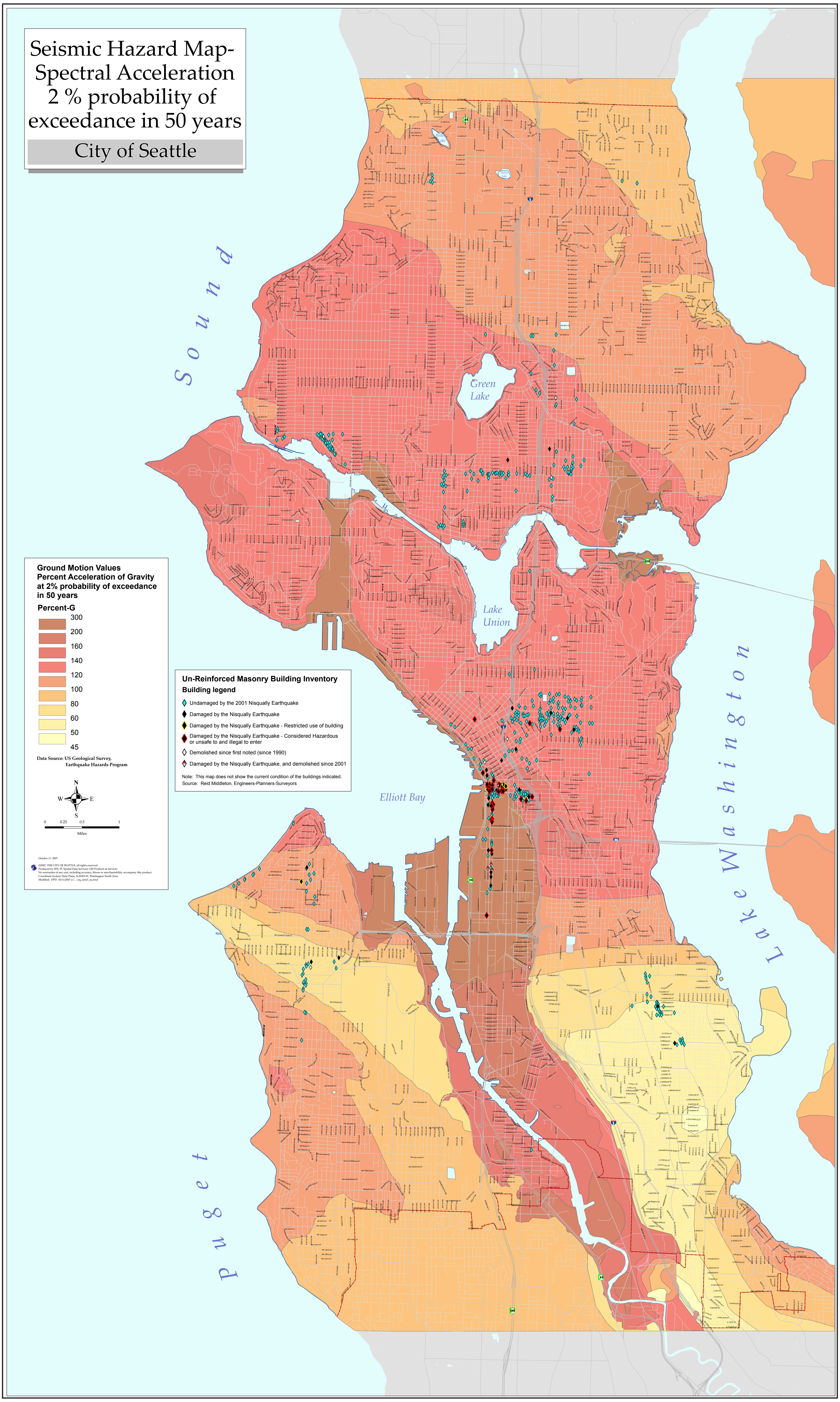
Since construction of URM buildings is no longer permitted, one of the ways to reduce the seismic risk posed by URM buildings is through demolition. Based on DPD's records, since 1990 the City has had a relatively low rate of 2 percent for building demolition when compared to other cities in similar areas of high seismic risk, such as San Francisco and Oakland, California.

2.2.2.1 Demolition of Surveyed URM Buildings in the City Since 1990

The City's Permit Status records indicate that 12 of the 575 URM buildings sampled have been demolished since 1990. This suggests the City has a demolition rate of about 2 percent over a 17-year time period. Table 2-2 indicates the demolition of these URM buildings has been citywide, with the SoDo District experiencing the most demolitions. This can also be seen in Figures 2 and 3.

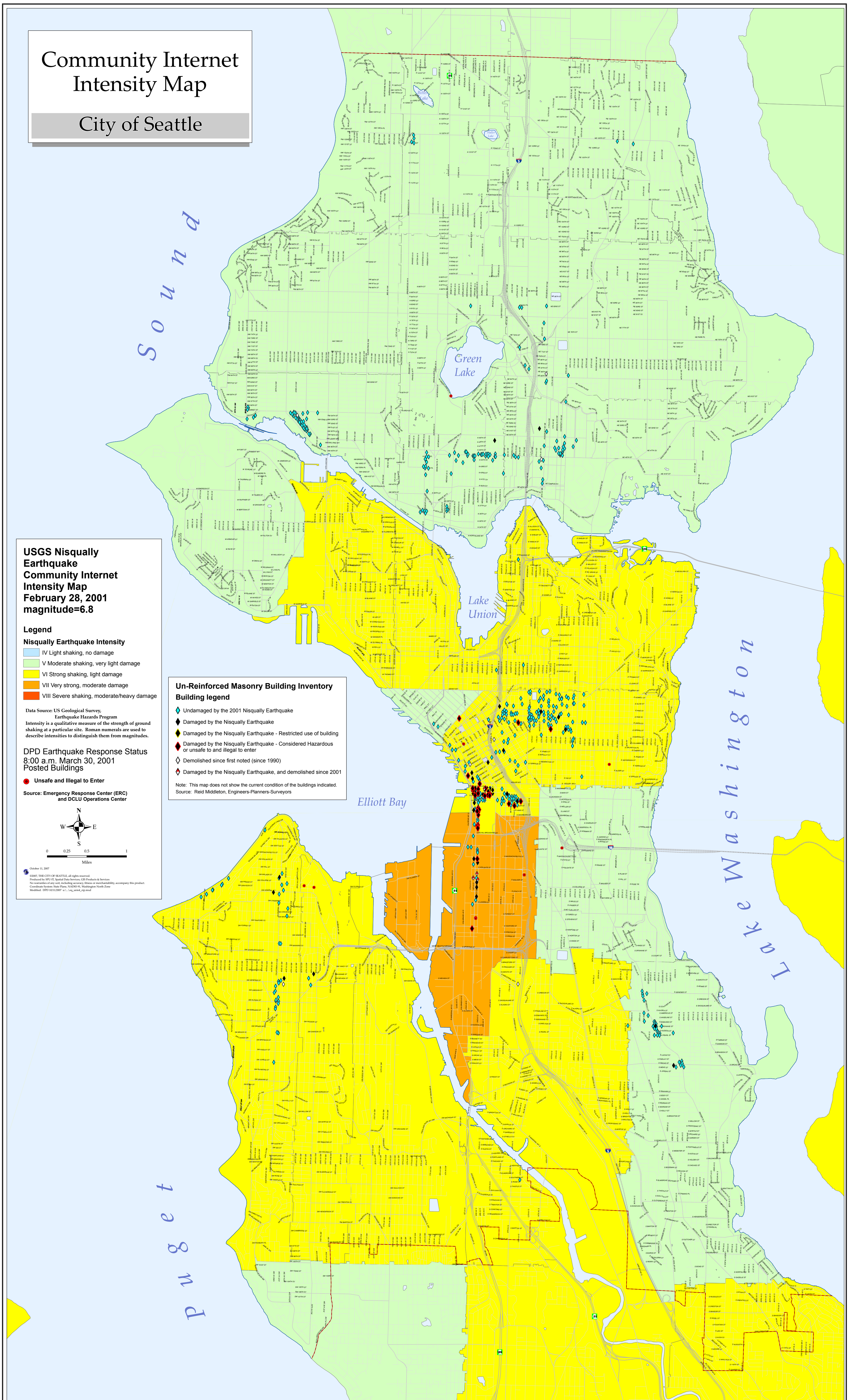
Table 2-2. Surveyed URM Buildings Demolished since 1990 by Neighborhood/Area.

Neighborhood/Area	Number of Surveyed URM Buildings Demolished
Roosevelt District	1
Wallingford	1
Ballard	1
First Hill	1
Pioneer Square	1
Downtown	1
South of Downtown District	5
West Seattle	1
Total	12

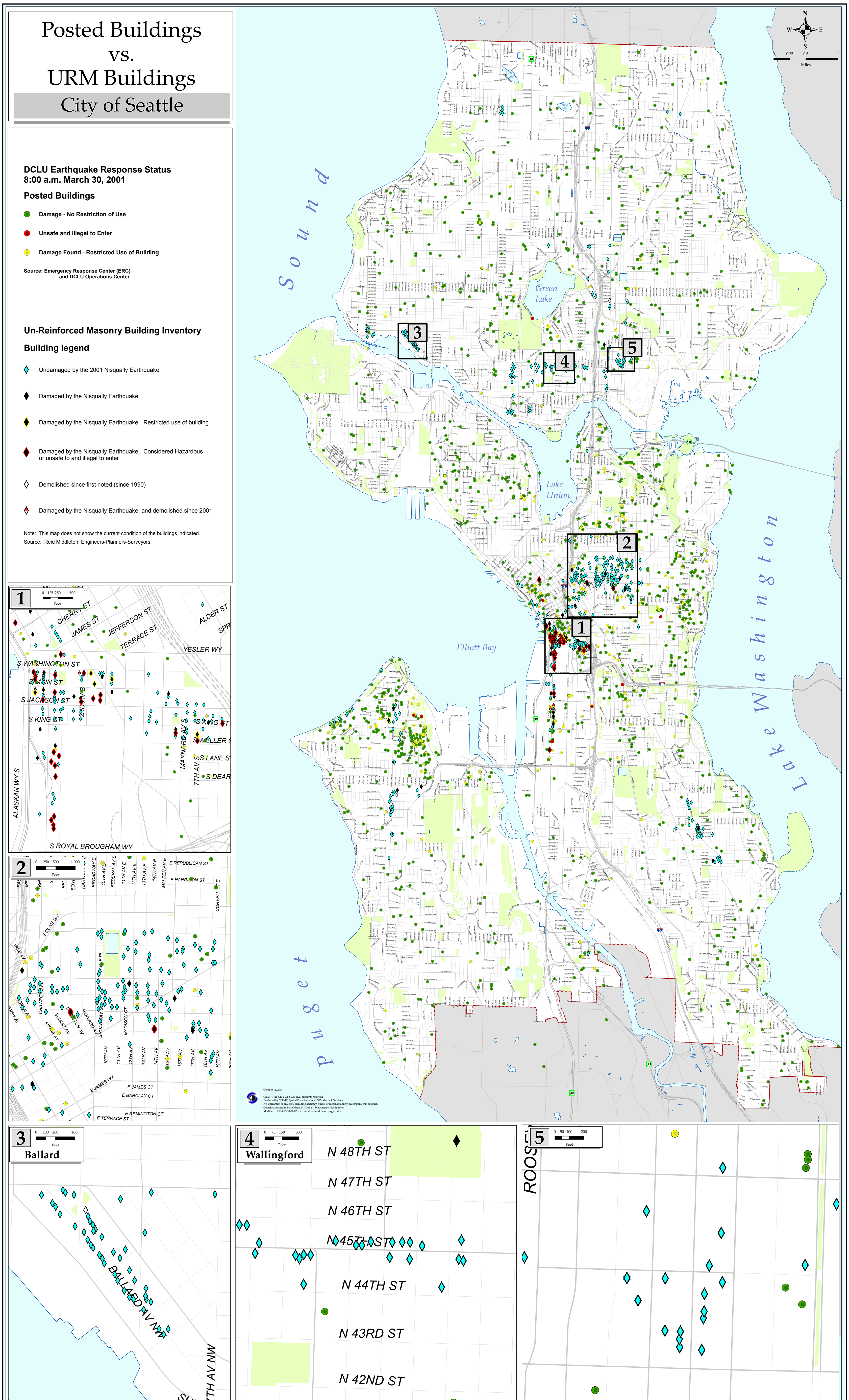


Seismic Hazard Map & Observed URM Buildings

Figure 2 - **Page 6**



Community Internet Intensity Map
City of Seattle
USGS Nisqually Earthquake Community Internet Intensity Map February 28, 2001 magnitude=6.8
Legend
Nisqually Earthquake Intensity
IV Light shaking, no damage
V Moderate shaking, very light damage
VI Strong shaking, light damage
VII Very strong, moderate damage
VIII Severe shaking, moderate/heavy damage
Data Source: US Geological Survey, Earthquake Hazards Program
Intensity is a qualitative measure of the strength of ground shaking at a particular site. Roman numerals are used to describe intensities to distinguish them from magnitudes.
DPD Earthquake Response Status
8:00 a.m. March 30, 2001
Posted Buildings
Unsafe and Illegal to Enter
Source: Emergency Response Center (ERC) and DCLU Operations Center
N
W
E
S
0
0.25
0.5
1
Miles
October 11, 2007
©2007, THE CITY OF SEATTLE, all rights reserved.
Produced by SPU-IT, Spatial Data Services, GIS Products & Services
No warranties of any sort, including accuracy, fitness or merchantability, accompany this product.
Coordinate System: State Plane, NAD83-91, Washington North Zone
Modified: DPD 10/11/2007 u:\..\eq_urm4_zip.mxd
Un-Reinforced Masonry Building Inventory
Building legend
Undamaged by the 2001 Nisqually Earthquake
Damaged by the Nisqually Earthquake
Damaged by the Nisqually Earthquake - Restricted use of building
Damaged by the Nisqually Earthquake - Considered Hazardous or unsafe to and illegal to enter
Demolished since first noted (since 1990)
Damaged by the Nisqually Earthquake, and demolished since 2001
Note: This map does not show the current condition of the buildings indicated.
Source: Reid Middleton, Engineers-Planners-Surveyors
Puget Sound
Green Lake
Lake Union
Elliott Bay
Lake Washington



ReidMiddleton

2.2.2.2 Seattle URM Demolition Rate Compared to Other Cities

The City of Seattle has a relatively low rate of demolition of URM buildings compared to other West Coast cities that have experienced significant earthquakes (see Table 2-3). Some reasons for this low rate may include protection and preservation of URM buildings in certain areas of the City, such as Pioneer Square, and the designation of other buildings within the City as historic landmarks. Given these efforts against demolition, it appears that upgrading the buildings may be a more expedient way to reduce seismic risk to the public posed by URM buildings.

Table 2-3. Demolition Rates of URM Buildings.

City	URM Demolitions from 1990 to 2003[2]
San Jose[1]	8%
Oakland[1]	7%
San Francisco[1]	6%
Berkeley[1]	1%
Seattle[2]	2%

[1] Data taken from EERI's Unreinforced Masonry Building Fact Sheet at www.quake06.org.
[2] Data taken through September 2007 from the DPD web site and used in conjunction with this and previous works' surveyed buildings.

2.2.3 Estimated Rate of Seismic Upgrades to URM Buildings

Another way to reduce the seismic risk posed by URM buildings is to upgrade the buildings to better resist earthquakes. Upgrades may include anchoring the masonry walls to the floor and roof diaphragms, anchoring parapets to the roof, securing potential falling hazards, and adding additional structure to the building to reduce the earthquake forces imparted to the bricks. Seismically upgrading URM buildings reduces the risk to the public posed by building damage or collapse.

2.2.3.1 URM Buildings in the City Since 1990

Based on the City's permitting records, the City has had a relatively low rate of URM building upgrades. From 1990 to the Nisqually earthquake in 2001, a total of 13 of the 575 surveyed URM buildings have had some form of seismic upgrade performed. Since the Nisqually earthquake in 2001, another 16 of the 575 buildings surveyed have had some form of seismic upgrade performed. Table 2-4 lists URM upgrades before and after the Nisqually earthquake by neighborhood and area.

Table 2-4. Upgraded URM Buildings Since 1990[1].

Area	Upgraded before 2001	Upgraded after 2001	Total
Northgate/Bitter Lake	0	0	0
Lake City	0	0	0
U-District/Roosevelt	0	1	1
Ballard	0	1	1
Wallingford	0	1	1
First Hill	1	0	1
Capitol Hill	3	1	4
Downtown	1	1	2
Pioneer Square	7	6	13
South of the Downtown	0	1	1
West Seattle	1	0	1
Columbia City	0	4	4
Totals	13	16	29

[1] Information taken from the DPD's Permit Status information system.

2.2.3.2 Seattle URM Seismic Upgrade Rate Compared to Other Cities

Compared to other major cities that may experience significant seismic events, Seattle's rate of seismically retrofitting URM buildings, based on City permit records, appears to be relatively low, as shown in Table 2-5. Note that the other cities listed in Table 2-5 have ordinances that require URM buildings be retrofitted. These cities are used as an indicator of what retrofit rate may be possible for Seattle.

Table 2-5. Rate of Seismic Upgrades of URM Buildings.

City	URM Buildings Upgraded from 1990 to 2003[2]
Oakland[1]	89%
San Jose[1]	85%
Berkeley[1]	79%
San Francisco[1]	62%
Seattle[2]	5%

[1] Data taken from EERI's Unreinforced Masonry Building Fact Sheet at www.quake06.org.
[2] Data taken through September 2007 from the DPD records and used in conjunction with this and previous studies.

The rate of seismic upgrades for Seattle is probably higher than indicated above. If the verbiage used for the renovations was not listed on the permit records, or if the seismic upgrade work was combined with other work on the building and only the other work was listed, then the rate of upgrades would appear to be lower than it actually is. An examination of the permit drawings for the work done would reveal whether seismic upgrades had been completed; however, the investigation of each building's permit drawings for every work and renovation is beyond the scope of this study's work.

2.2.4 Summary of Current URM Seismic Risk Reduction Regulations

2.2.4.1 Oakland, California

The City of Oakland has had most of its known, potential seismically hazardous URM buildings retrofitted over the last 15 years. Oakland has experienced economic redevelopment and reinvestment in recent years from private sector investments. Through City Ordinances, the City has taken advantage of this redevelopment and reinvestment to have the new owners pay for upgrading existing URM buildings that have been identified as potential seismic hazards.

City Ordinance 15.28 gives the Building Official authority to establish a list of URM buildings within the City limits and deem them as potential hazards. Those buildings are mandated to be upgraded to the Uniform Code of Building Conservation (UCBC) or face penalties. Typical UCBC stated upgrades to the building would include:

1. Attaching the walls to the floor and roof;
2. Bracing the parapets;
3. Removing or securing falling hazards; and,
4. Protecting exit ways from falling hazards.

The penalties for failure may include:

1. Fines that may exceed $10,000 for not meeting the requirements of Ordinance 15.28 within the specified time frame.
2. Notification to lenders and lien holders that the building is not in compliance with City ordinances.
3. Posting and maintaining a sign at the building entry, at the Owner's expense, that states the building is considered a potentially hazardous URM building.
4. Building Official may revoke the certificate of occupancy.
5. Building Official may withhold or deny issuance of permits.
6. Building Official may suspend existing permits.

It appears that, through the economic redevelopment of Oakland from private funding and the enforcement of Ordinance 15.28, upgrades and renovations of URM buildings have taken place. Typically, seismic improvements to the building have been done in the course of changing ownerships, allowing the new owner to change the building to meet their needs only if these upgrades are completed.

2.2.4.2 Berkeley, California

The City of Berkeley has also had a reduction in unretrofitted URM buildings since 1990. The City of Berkeley has similar city ordinances to those of Oakland and has experienced private money upgrading URM buildings. As with Oakland, the City of Berkeley established a list of potentially hazardous URM buildings under Title 19, Chapter 38, Section 020 (19.38.020), of the City Code. Under 19.38.030, unless the building official deems it unnecessary, the upgrade of the building will include:

1. A registered engineer for the design of the retrofit of the building.
2. A testing agency.
3. Special inspection to insure compliance with the approved construction documents.

Under 19.38.040 and 19.38.060, the City of Berkeley has limited the time given to owners of buildings listed as potentially hazardous to upgrade their URM buildings. If the owner fails to seismically upgrade the building within the allotted time limit, then by 19.38.040 and 19.38.070 the owner is obligated to:

1. Notify the residents of the building that the building is a potentially hazardous URM building.
2. At the Owner's expense, post and maintain a sign on the building that states the building to be a potentially hazardous building.

Also note, under 19.38.060, the schedule for seismic upgrades can be accelerated if the building goes through remodeling, alteration, or significant structural repairs. The schedule for seismic upgrades can also be accelerated with the sale or transfer of title, except through inheritance, to be within 6 months of the transfer.

It appears that with the economic development within the City of Berkeley (through private investments) and the City's emphasis on seismically upgrading the URM buildings, the City of Berkeley has seen 629 of the City's approximately 729 URM buildings become compliant with the UCBC as of 2003 (EERI, 2004).

3.0 Findings

3.1 Possible Damage Patterns to URM Buildings from the Nisqually Earthquake

Through identifying patterns of seismic damage in URM buildings, the seismic risk may be reduced by focusing efforts on rectifying or reducing the impact of these characteristics. Some characteristics of concern include the number of stories comprising the building, the location of the building within the City, and the year the URM building was constructed.

3.1.1 Number of URM Building Stories

The 575 URM buildings noted in this study were categorized by characteristics such as the number of stories and whether the building permit record indicated the structure suffered damage due to the 2001 Nisqually earthquake. Although buildings with three or more stories comprised a majority of the damaged buildings after the Nisqually earthquake, one- and two-story buildings comprised a significant portion, approximately 17 and 15 percent, respectively, as shown in Table 3-1. More notable is that a significant portion of these one- and two-story buildings were in areas where the shaking was considered to be less than the shaking in Pioneer Square.

Table 3-1. Story Investigation of Buildings Damaged by the Nisqually Earthquake[1].

Number of Stories	Number of Damaged Buildings	Percent Damaged
7	1	1%
6	6	8%
5	11	15%
4	15	20%
3	17	23%
2	11	15%
1	13	18%
Total	74	100

[1] Information taken from the DPD's Permit Status information system.

The 2001 Nisqually earthquake is considered a deep earthquake, occurring approximately 32 miles below the ground surface. A deep earthquake is one with a hypocenter, or point of origin, that occurs at depths greater than 20 miles below the surface. The ground tends to attenuate, or filter out, higher frequency (shorter-period) ground motions from earthquakes, leaving longer-period motions reaching the ground surface. In the event of a shallow earthquake, such as the rupturing of the Seattle Fault, this attenuation of high frequency ground motion will likely be minimal. Hence, buildings with short and long natural time periods (short and taller buildings, respectively) may resonate with this earthquake and experience more motion, resulting in increased damage.

The following tables summarize damage recorded in the sample set of URM buildings surveyed. The results of the tables may indicate what damage patterns the City could experience in the future. Even though the Nisqually earthquake was a deep earthquake, a significant number of buildings damaged were buildings with natural periods of less than 1 second, such as the one- to four-story buildings noted in the tables.

Three-story URM buildings are found throughout the city in significant percentages; they are not confined to the Downtown, International District, or Pioneer Square areas. Three-story URM buildings are also common in Wallingford, the University and Roosevelt Districts, and West Seattle, where they amount to approximately 19, 24, and 21 percent, respectively, of the URM buildings recorded in this study. These high percentages, combined with being the statistical mode, or most damaged type of URM building during the Nisqually earthquake, prompted special consideration for three-story buildings in this study. Table 3-2 compares the number of stories in damaged buildings to their location within the City.

Table 3-2. 2001 Nisqually Earthquake Damaged URM Buildings: Stories vs. City Area[1].

Location/Area	1 and 2 Stories		3 Stories		4 or More Stories		Total
	No. of Bldgs	Percent	No. of Bldgs	Percent	No. of Bldgs	Percent	Percentage
Northgate/Bitter Lake	0	0%	0	0%	0	0%	0%
Lake City	0	0%	0	0%	0	0%	0%
Roosevelt/U-District	1	1%	0	0%	0	0%	1%
Ballard	0	0%	0	0%	0	0%	0%
Wallingford	0	0%	1	1%	0	0%	1%
First Hill	0	0%	0	0%	3	4%	4%
Capitol Hill	3	4%	0	0%	1	1%	5%
Downtown	2	3%	3	4%	1	1%	8%
Pioneer Square/ International District	7	10%	10	14%	26	35%	58%
South of the Downtown	8	11%	1	1%	1	1%	14%
West Seattle	1	1%	2	3%	1	1%	5%
Columbia City	2	3%	0	0%	0	0.00%	3%
Total	24	33%	17	23%	33	45%	100%

[1] Information taken from the DPD's permit information system.

3.1.2 URM Parapet and Other Damage

Unretrofitted URM buildings are known to suffer damage from earthquakes. Parapets on URM buildings have historically been a significant source of damage and pose a falling hazard. Table 3-3 shows the extent of damage to those buildings noted as damaged in the over 500 buildings surveyed and attempts to investigate other areas that were damaged from the Nisqually earthquake. Of the 74 buildings damaged, 18 buildings (approximately 24 percent), were found to have damaged parapet. However, 46 buildings were identified in the City's permit record system as having damaged walls. Table 3-3 also notes other damaged areas that needed repair.

Table 3-3. Number of URM Buildings Damaged: Area of Damage and Building Location in the City.

Area	Parapets	Exterior Walls			Stairwell/ Elevator	Floor Joist/ Diaphragm	Chimneys	Penthouse	Foundation
		East-West	North-South	No Direction Indicated					
Northgate/ Bitter Lake	0	0	0	0	0	0	0	0	0
Lake City	0	0	0	0	0	0	0	0	0
U-District/ Roosevelt	1	0	0	1	0	0	0	0	0
Ballard	0	0	0	0	0	0	0	0	0
Wallingford	0	0	1	0	1	0	0	0	0
First Hill	2	0	1	0	0	0	0	0	0
Capitol Hill	0	1	0	1	1	2	1	0	0
Downtown	1	1	0	1	0	0	2	0	0
Pioneer Sq/ International	10	11	10	7	7	4	1	4	2
South of the Downtown	0	3	3	2	0	1	0	0	1
West Seattle	2	0	0	3	0	0	3	0	0
Columbia City	2	0	0	0	0	0	0	0	0
Total	18	16	15	15	9	7	7	4	3

Note: Some buildings had more than one type of damage, while other buildings listed as red- or yellow-tagged or hazardous did not have records indicating what type of damage the building suffered. Hence, Table 3-3 will not sum to 74 buildings.

3.1.3 URM Building Vintage

The year of construction for the URM buildings was also examined to determine whether the building vintage was directly related to damage. As Tables 3-4 and 3-5 indicate, the buildings most damaged by the Nisqually earthquake appear to be those that are also the most common vintage citywide. Since the majority of damaged URM buildings occurred in Pioneer Square, the ages of buildings surveyed in this area were crossed-referenced with ages of buildings noted as damaged Citywide. Hence, there appears to be no correlation between the age of the URM building and the likelihood of damage during the Nisqually earthquake.

Table 3-4. Year of Construction for Surveyed URM Buildings Damaged During the Nisqually Earthquake.

Year Built	Number of Damaged URM Buildings	Percent
Before 1901	16	22%
1901-1910	29	39%
1911-1920	9	12%
1921-1930	13	18%
1931-1940	1	1%
Unknown	6	8%

Note: Not all damage surveyed had the year of construction listed in either King County or City of Seattle record systems.

Table 3-5. Year of Construction for Surveyed URM Buildings in Pioneer Square.

Built	Number of URM Buildings	Percent
Before 1901	33	25%
1901-1910	51	39%
1911-1920	16	12%
1921-1930	10	8%
1931-1940	2	2%
Unknown	20	15%

Note: Not all buildings surveyed had the year of construction listed in either King County or City of Seattle record systems.

Limitations of Existing Public Records

Note that when comparing the City's address of a building to King County's address for the same building, the addresses did not always match. Similarly, the King County records did not always indicate the actual year of the building's construction. One example is the AME Church on Capitol Hill. The tax records did not indicate the older parts of the structure, such as the sanctuary, but gave the year of the church's new addition as the year of construction for the entire complex.

3.2 Pre-Nisqually Earthquake Seismic Upgrade Details

3.2.1 Typical Upgrade Details from Nisqually Earthquake Damaged Buildings

The DPD permit record database indicates that of the 13 URM buildings upgraded before 2001, six suffered seismic damage from the 2001 Nisqually earthquake. As Table 3-6 shows, most of the upgraded buildings that were damaged were located in Pioneer Square, the International District, and Downtown areas. Most structural upgrades to these 13 buildings included bracing the parapets to the roof at 4- to 8-foot spacing and connecting the wall to the floor or roof diaphragms at 4-foot spacing. Out of the seven buildings indicated as having some form of seismic upgrade in the Pioneer Square/International District area, five buildings reported significant damage due to the Nisqually Earthquake. The two buildings that did not report damage both had additional lateral system(s) added as part of their retrofitting. The additional structure may have increased the building's ability to resist earthquakes by reducing the forces to the brick piers. Please note that the sample size for this survey is relatively small, making it difficult to establish trends with certainty.

Table 3-6. Upgraded URM Buildings before 2001[1]

Neighborhood	Upgraded [1]	Damaged	Damaged and Posted "Limited Entry"
Northgate/Bitter Lake	0	0	0
Lake City	0	0	0
U-District/Roosevelt	0	0	0
Ballard	0	0	0
Wallingford	0	0	0
First Hill	1	0	0
Capitol Hill	3	0	0
Downtown	1	1	0
Pioneer Square/ International District	7	5	2
South of the Downtown	0	0	0
West Seattle	1	0	0
Columbia City	0	0	0
Totals	13	6	2

[1] Information taken from the DPD's Permit Status records.

4.0 Options to Manage Risk

Allocation of financial resources is a large factor in determining what course of action to take when mitigating seismic risk. To have a sense of the order of magnitude of cost, this section develops a range of costs for upgrading URM buildings to a standard that should improve their seismic safety. The Federal Emergency Management Agency (FEMA) Life Safety standard, from FEMA 356, was used in conjunction with FEMA 157 and FEMA 276 cost data. Briefly, the FEMA 356 Life Safety standard is intended as a level at which the building will probably suffer structural damage to the lateral system during a design level earthquake, but should not collapse. This standard is also intended to minimize falling hazards from the building and allow for adequate emergency egress.

4.1 FEMA 157 and FEMA 276 Upgrade Cost Estimates

Estimates of upgrade or retrofit costs for URM buildings were based on FEMA 157 and FEMA 276. For statistical purposes and to not give a false sense of certainty in the estimates, a confidence range of 50 percent was selected. Also, to address inflation since the publication of these FEMA documents, a 3 percent annual rate of inflation was used. The upgrade costs shown in Table 4.1 are presented in 2007 dollars.

The typical structural-only upgrade costs include the group mean cost for URM type buildings, an area adjustment to account for the average size URM building (per City neighborhood/area), and factors that recognize buildings in Seattle are in an area of high seismicity. Additionally, estimates were made for the approximate number of URM buildings within the City's area, as well as the rate of upgrades noted in this survey. In recognition of the limited scope of this survey and that only 9 percent of the City's area has been investigated, the number of estimated buildings that may need to be upgraded was calculated using the total number of estimated buildings minus the estimated number of buildings that have been upgraded since 1990.

The total number of buildings was approximated by using the total number of observed buildings plus a range of URM buildings per square mile for those areas of the City that have not been investigated. A range of URM densities from 3.8 to 4.6 URM buildings per square mile was used in calculating the remaining number of URM buildings in those uninvestigated areas. These densities are likely at the low end of what was observed in this study, in order to avoid overexaggerating the number of URM buildings within the City limits. For the estimated number of buildings that have been upgraded since 1990, a density of twice that observed from reviewing the City's permitting records was used. This density was to account for upgraded URM buildings that were not recorded as such in the City's records. Due to the size and special nature of the Union Street Station, it was removed from the data, both for estimating the average size of URM buildings in the Pioneer Square area and for estimating repair costs, due to its extensive repairs in the 1980s and 1990s.

Upgrading or retrofitting a building typically involves costs in addition to structural costs. The typical total project costs use the structural costs described above and include an amount for architectural/nonstructural costs and handling possible hazardous materials, but exclude historical preservation and disabled access upgrade costs. As a result, the total project cost, without the aforementioned exclusions, is approximately 2.5 times the structural-only costs.

Table 4-1. Estimated URM Structural-only Upgrade Costs[1] (2007 Dollars).

Neighborhood/Area	Average/Model Building Gross Area (square feet)	Lower Bound Cost Estimate ($ Million)	Upper Bound Cost Estimate ($ Million)
Ballard	7,000	11.1	13.6
Greenwood/Broadview	5,500	3.4	4.6
Northgate/Bitter Lake	5,500	2.5	3.4
Lake City	19,300	7.7	11.2
Wallingford/Fremont	9,000	16.0	19.5
U-Dist./Roosevelt	19,800	29.2	37.5
Capitol Hill/Cascadia/Central	19,200	59.4	68.8
Queen Anne/Magnolia	5,500	4.3	6.1
Downtown/First Hill	41,500	59.4	70.9
Pioneer & International Dist.	36,900	95.7	106.8
SoDo & Industrial Dist.	37,900	24.0	30.2
West Seattle	15,000	34.1	44.5
Beacon Hill/Rainier Valley/ Columbia City	6,900	11.1	14.2
Totals	--	$358.0M	$431.5M

[1] To upgrade to the FEMA 356 Life Safety Performance Level.

4.2 Repair Costs of the Nisqually Earthquake vs. Upgrade Costs

The apparent costs of the 2001 Nisqually earthquake were estimated using data from the City's permit history records. Note that in cases where the records indicate repairs and upgrades, half the total cost was taken as repair costs for estimating purposes. As with the upgrade costs indicated in Section 4.1, a 3 percent per year rate of inflation was used to adjust the costs from fiscal year 2001 dollars to 2007 dollars. In recognition that only part of Seattle has been surveyed for this study and that not all seismic repair work done after the Nisqually earthquake was recorded in the City's permit history, the repair costs noted in the sample of URM buildings was multiplied by the ratio of likely URM buildings in the area to the number of buildings sampled for this study. Additionally, areas where no buildings were surveyed, such as the Queen Anne/Magnolia area, have been removed from Table 4-2.

The estimated cost of the Nisqually earthquake, in terms of the total area of the City and 2007 dollars, is approximately $12.8 million, totaled in Table 4-2. This amount does not include costs for residential chimney repair or the costs for buildings that the City records listed as hazardous but did not indicate a cost for repairs. Also note that the Nisqually earthquake was not the largest seismic event that the area is expected to endure. Estimates of the Seattle Fault earthquake predict two to three times the maximum ground acceleration as compared to the

Nisqually earthquake (Yamatsuka and Siu, 2002). Hence, those areas that show no damage costs for the Nisqually earthquake are likely to have repair costs for a larger event.

Table 4-2. Estimated Nisqually Earthquake vs. Structural-only Upgrade URM Costs[1] (2007 Dollars).

Neighborhood/Area	Apparent Total Cost Due to Nisqually Earthquake	Lower Bound Cost Estimate ($ Million)	Upper Bound Cost Estimate ($ Million)
Ballard	None Indicate (NI)	11.1	13.6
Greenwood/Broadview	NI	3.4	4.6
Northgate/Bitter Lake	NI	2.5	3.4
Lake City	NI	7.7	11.2
Wallingford/Fremont	0.1	16.0	19.5
U-Dist./Roosevelt	3.6	29.2	37.5
Capitol Hill/Cascadia/ Central	0.9	59.4	68.8
Queen Anne/Magnolia	Not Surveyed	4.3	6.1
Downtown/First Hill	0.9	59.4	70.9
Pioneer & International Dist.	6.5	95.7	106.8
SoDo & Industrial Dist.	0.6	24.0	30.2
West Seattle	0.1	33.9	44.4
Beacon Hill/Rainier Valley/ Columbia City	0.1	11.4	14.5
Totals	$12.8M	$358.0M	$431.5M

[1] To upgrade to the FEMA 356 Life Safety Performance Level.

4.3 Economic Loss and Casualty Considerations

In addition to the cost of property damage to Seattle's URM buildings, other factors such as economic losses and human casualties should be considered. In order to try to estimate these two factors, the EERI's 2005 Seattle Fault Scenario was chosen for their research conducted on this scenario. Please note that it is not the worst-case earthquake that could strike Seattle.

The EERI study considers the impacts to the Central Puget Sound region of a magnitude 6.7 earthquake caused by a Seattle Fault rupture. Under this scenario, the economic loss to the region around Seattle associated with businesses' inability to operate was estimated at $3.8 billion in 2004 dollars. Using a 3 percent annual rate of inflation, the estimated cost in 2007 dollars is approximately $4.2 billion. To translate this cost for the region to that for the City of Seattle, a ratio based on population was used. From the 2000 U.S. Census Bureau, the ratio of the City's population to that of the region (approximated by King, Pierce, and Snohomish Counties) was 1 to 5.6, or approximately 18 percent. Thus, the economic loss to the City of Seattle due to businesses' inability to operate is estimated to be approximately $740 million.

The URM building contribution to Seattle's losses due to the magnitude 6.7 Seattle Fault Scenario earthquake is estimated to be 5 to 10 percent of the total losses. This range reflects the cost of damage to URM buildings caused by the Nisqually earthquake; of the more than $200 million in damage suffered by the City in total (Yamatsuka and Siu, 2002), the Nisqually earthquake caused over $8 million in property damage to URM buildings. This range of 5 to 10 percent was applied to both the projected economic loss and estimated casualties indicated in EERI's Seattle Fault Scenario earthquake. Table 4-3 shows what the possible estimated casualties directly related to URM buildings might be in the Seattle Fault Scenario, based on the above assumptions.

Table 4-3. Estimated Casualties due to URM Buildings in the Seattle Fault Scenario Earthquake [1].

	Estimated Total Number of Casualties in Seattle due to URM Buildings	
Estimated:	Low Estimate (5% of Total)	High Estimate (10% of Total)
Number of Deaths	15	30
Number of Life-Threatening Injuries	8	15
Injuries Requiring Hospitalization	47	94
Minor Injuries	163	327
Total Casualties	233	466

[1] Based on data from EERI's Seattle Fault Scenario, 2005.

Table 4-4 estimates the possible range of costs directly related to URM buildings due to both casualties and economic losses. Table 4-4 may underestimate the impact of the Seattle Fault Scenario earthquake, because unretrofitted buildings typically suffer more damage and are more likely to collapse than other types of buildings. Additionally, a shallow earthquake will likely not have as many frequencies attenuated, unlike the deep-seated Nisqually earthquake.

As for the costs associated with casualties, 3 percent of the total cost from both the direct capital costs and the economic losses due to businesses' inability to operate was used (Porter, Shoaf, and Seligson, 2006). From the 1994 Northridge earthquake, the cost to treat casualties was estimated at 3 to 4 percent of the total from direct property damage and economic loss due to businesses being unable to operate as before the earthquake. The Northridge earthquake is referenced due to its similar characteristics to the Seattle Fault scenario: the Northridge Earthquake is relatively recent, was a similar 6.7 magnitude, and was a shallow earthquake (occurring at approximately 10 miles below the ground surface). Hence, this 3 percent was chosen and noted as the low end of the range.

Table 4-4. Estimated Costs: URM Buildings in the Seattle Fault Scenario Earthquake [1] (2007 Dollars).

Estimated:	Total Costs due to URM Buildings [2] Low Estimate (5% of Total, $ Million)	Total Costs due to URM Buildings [2] High Estimate (10% of Total, $ Million)
Cost from Building Damage[2]	13	13
Economic Loss [1]	38	75
Cost due to Casualties[1]	2	3
Total	$53M	$91M

[1] Based on data from EERI's Seattle Fault Scenario, 2005.
[2] Based on data from Table 4.2.

Although the estimated total cost from Table 4-4 is less than the cost to retrofit or upgrade the URM buildings to FEMA Life Safety standards, it should be noted that the costs indicated for URM building damage are low estimates based on the Seattle Fault Scenario. In a larger magnitude earthquake, the financial impacts to Seattle could be markedly different than those predicted above.

In addition to the above focus on casualties, an estimate of the different casualty rates due to different building conditions is considered here. Currently, it appears most unretrofitted URM buildings would be significantly damaged during a major earthquake. By seismically upgrading the unretrofitted URM buildings to FEMA 356 Life Safety standards, the performance of URM buildings can be expected to improve significantly. In Jack Moehle's 2003 paper, "A Framework for Performance-Based Earthquake Engineering," seismically retrofitting a building can significantly reduce the chance the building will cause casualties during a major earthquake. By upgrading a building from the point that the building is near collapsing during a design level earthquake to FEMA 356 Life Safety level of performance, the number of casualties can be significantly reduced. Moehle estimated the number of casualties can be reduced from 250 casualties per 1000 building occupants to as low as 1 casualty per 1000 occupants.

5.0 Conclusions

5.1 Extent and Location of URM Buildings

There appears to be a minimum of 850 to 1000 URM buildings within the City of Seattle. The City's URM buildings have concentrations throughout the City, from the University and Roosevelt District in the north to Columbia City and West Seattle in the south and west. Most of the buildings surveyed appear to be in areas that are expected to be subjected to some of the highest seismic forces within the City.

5.2 Risk Posed by URM Buildings

In their rapid visual screening document, the Applied Technology Council (ATC) recommends that URM buildings have detailed evaluations performed. The base evaluation number used to start the scoring process on the ATC form is less than the minimum number at which the ATC recommends a detailed analysis be performed. The further below this minimum number, the more probable the building will perform poorly in an earthquake. Hence, the City's URM buildings appear to be at high risk to experience damage in a design level earthquake, based on the finding of the sample set.

5.3 Typical Damage Area

Historically, common areas of damage to URM buildings caused by earthquakes include parapets, walls, stairwells and elevators, wall to floor diaphragm connections, and chimneys. The City's permit records indicate significant numbers of buildings sustained damage in these areas as a result of the 2001 Nisqually earthquake. Failed parapets and walls were the most common types of damage indicated in the records. This type of failure poses a safety risk to the occupants of the building and to public outside due to falling debris and possible collapsing of part of the structure.

5.4 Mitigation Efforts

From 1990 to the 2001 Nisqually earthquake, the permit records indicate that 13 of the 575 URM buildings noted in the sample set had some form of seismic retrofitting performed. Of these buildings, six were noted in the records as being damaged. Since a significant portion of damaged URM buildings (retrofitted and unretrofitted) occurred in the Pioneer Square and International districts, it was noted that five of the seven buildings in these districts that had some form of retrofitting performed sustained damage in the Nisqually earthquake. The two that did not appear to sustain significant damage had additional structure added in what appears to be an effort to assist the building's lateral system.

5.5 Impacts and Upgrade Costs

In an effort to estimate future costs associated with earthquakes, the 2001 Nisqually earthquake records for the 575 URM buildings in the sample set and the Earthquake Engineering Research Institute's (EERI) 2005 Scenario for a magnitude 6.7 earthquake on the Seattle Fault were