



Seattle Fault Earthquake Scenario

Conference

February 28, 2005



Earthquake Engineering
Research Institute



Essential Facilities

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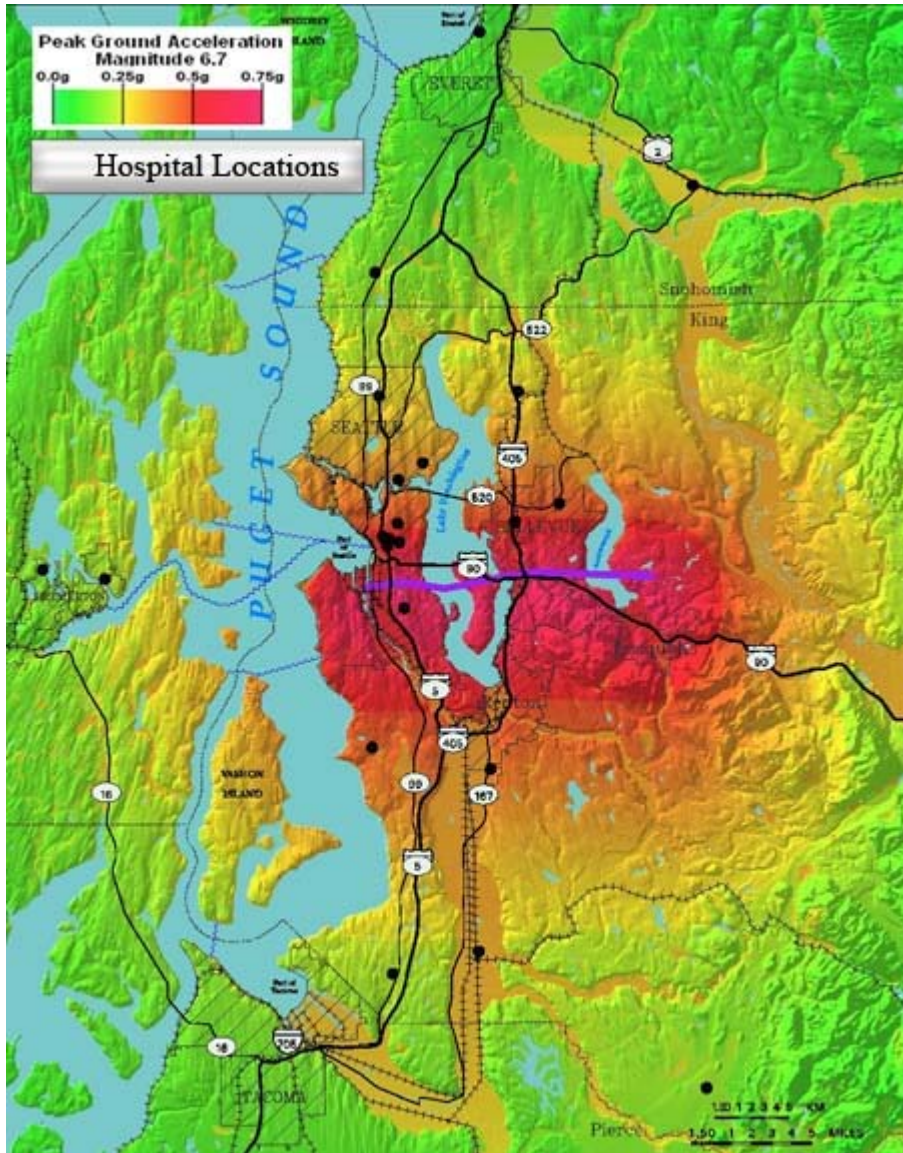


SEAW Essential Facilities Team

| Engineer | Task | Organization |
|-----------------------------|---------------------------|--|
| Stacy Bartoletti, PE, SE | Hospitals, Team Leader | Degenkolb Engineers, Inc. |
| Doug Wilson, PE | Fire Stations | Reid Middleton, Inc. |
| Brian Zagers, PE | Police Stations | Coughlin Porter Lundeen, Inc. |
| Jack Wiggins, PE, SE | Schools | Quantum Consulting Engineers, LLC. |



Overview of Hospitals



- 25 Hospitals in Region
- 6,300 licensed hospital beds
- Age of construction varies but is generally post 1960's
- Construction generally consist of steel and cast in place concrete



Hospitals Performance in Past EQ's

- 1989 Loma Prieta - 112 Bay Area Hospitals Impacted. None fully closed.
- Structurally performed well - post 1973 Hospital Seismic Safety Act.
- All hospitals resumed regular operations within 48 hours.
- Key Issues - Hospitals and Government to improve communications and nonstructural damage.



Hospitals Performance in Past EQ's

- 1994 Northridge (M6.8)
- Property losses of \$20B, 61 deaths, 7,000 injured, 50,000 homeless.



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Hospitals Performance in Past EQ's



Olive View Hospital



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Hospitals Performance in Past EQ's



VA Sepulveda - NS Damage

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Hospitals Performance in Past EQ's

- 1995 Kobe (M 7.2)
- \$1.1B damage to hospitals.
- 193 of 222 hospitals experienced some damage in Hyogo Prefecture.
- Kobe - 103 of 112 hospitals damaged, 763 of 1,363 clinics damaged.
- Many hospitals unable to provide ordinary services.
- Widespread nonstructural damage.



Hospital Damage Projections

- Greatest damage near fault in regions of high ground motions.
- Concrete damage will consist of cracking and spalling.
- Potential for steel frame damage to moment frames and braced frames.
- Nonstructural damage will be significant.
- Potential short-term loss of utility service.



Hospital Damage Projections

Table 6-1: Estimate of Number of Available Hospital Beds at Various Time Periods Following Event

| Time After Event | King County (4,400 Total Beds) | | Pierce County (1,400 Total Beds) | | Snohomish County (500 Total Beds) | |
|------------------|-----------------------------------|------------------|-------------------------------------|------------------|--------------------------------------|------------------|
| | # Beds Available | % Beds Available | # Beds Available | % Beds Available | # Beds Available | % Beds Available |
| 1 Day | 1,100 | 25% | 1,110 | 79% | 380 | 76% |
| 3 Days | 1,370 | 31% | 1,160 | 83% | 400 | 80% |
| 7 Days | 1,720 | 39% | 1,230 | 88% | 420 | 84% |
| 30 Days | 2,910 | 66% | 1,340 | 96% | 480 | 96% |
| 90 Days | 3,470 | 79% | 1,390 | 99% | 490 | 99% |



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Predicted Casualties

| | | Level 1 | Level 2 | Level 3 | Level 4 |
|---|--------------|---------------|---|------------|--------------|
| 2 AM | Residential | 5,003 | 1,014 | 98 | 184 |
| | Non – Res. | 585 | 170 | 28 | 55 |
| | Commute | 2 | 2 | 3 | 1 |
| | Total | 5,589 | 1,187 | 129 | 239 |
| 2 PM | Residential | 1,381 | 281 | 27 | 51 |
| | Non – Res. | 17,908 | 5,157 | 840 | 1,661 |
| | Commute | 8 | 10 | 17 | 3 |
| | Total | 19,296 | 5,449 | 884 | 1,715 |
| 5 PM | Residential | 1,640 | 334 | 32 | 61 |
| | Non – Res. | 7,531 | 2,184 | 357 | 705 |
| | Commute | 22 | 30 | 50 | 10 |
| | Total | 9,175 | 2,547 | 439 | 776 |
| Level 1 – Medical Attention but not Hospitalization | | | Level 3 – Hospitalization and can become Life-Th. | | |
| Level 2 – Hospitalization but not Life-Threatening | | | Level 4 - Deaths | | |



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Hospital Impacts and Recovery Issues

- Damage to NS systems will be a major issue.
- Impacts to current patients due to potential hospital shut downs?
- Are hospitals prepared for significant number of injuries?
- Damage to transportation system and life lines will have a significant impact on ability to function and get patients to hospitals.

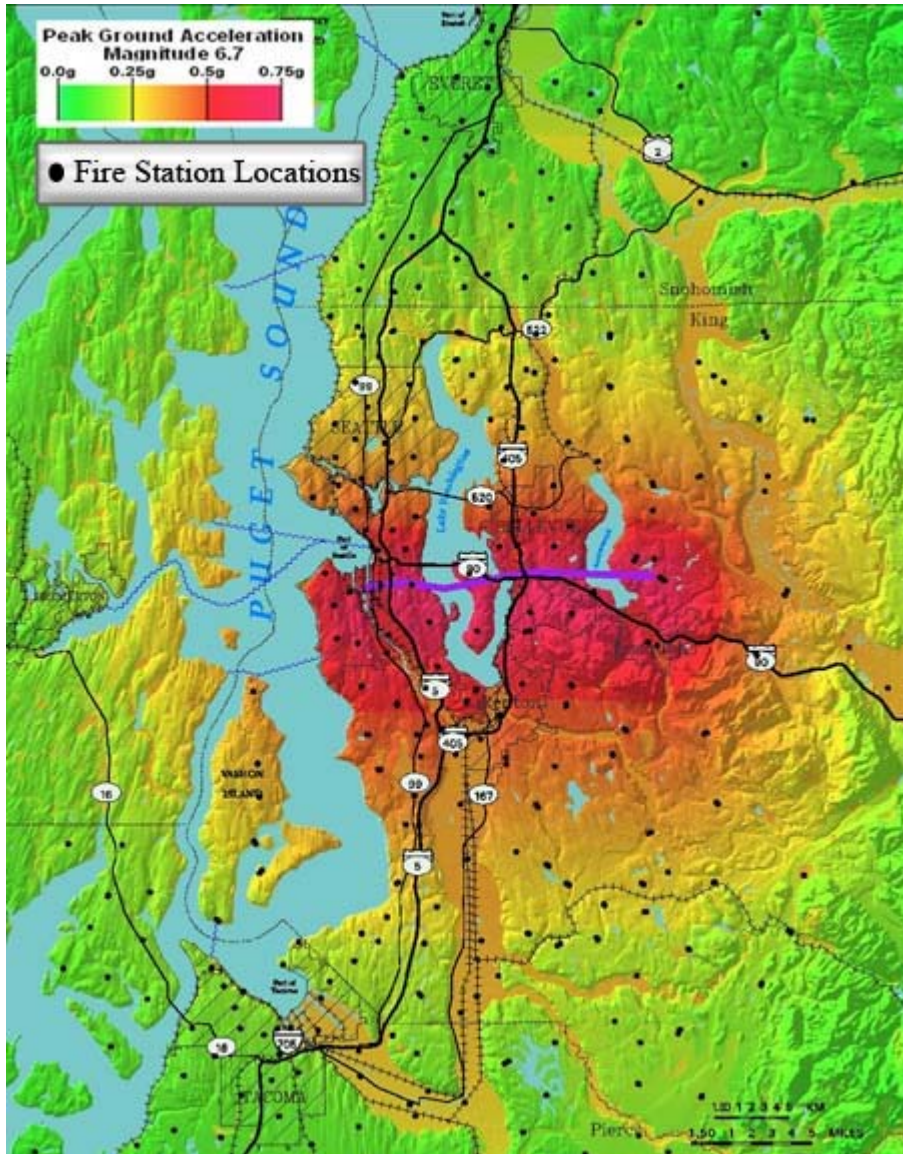


Hospital Recommendations

- Phase out and/or upgrade older poor performing hospital structures.
- Evaluate nonstructural seismic performance and upgrade.
- Consider performance based design for new facilities to ensure immediate occupancy of critical facilities.
- Hospitals need to be prepared to assess damage to facilities immediately following EQ.



Overview of Fire Stations



- Over 350 fire stations in region
- Distribution proportionate to population
- Vary in size and construction type
- Unique features include bay doors and hose towers



Overview of Fire Stations

- Generally older than average building stock
 - May mean poorer seismic performance
- Common construction types include:
 - Wood Frame
 - Reinforced Masonry
 - Cast-in-place Concrete
 - Precast Concrete



Fire Stations Performance in Past EQ's

- Apparatus bay doors jamming.
- Damage to apparatus.
- Partial or complete collapse of structures.
- Non-structural damage (sprinklers, equipment, and ceilings) resulting in reduced functionality.



Fire Station Damage Projections



Fire station at Olive View Hospital damaged in the 1971 San Fernando, California earthquake

- Similar or worse than surrounding buildings
- Most significant in Seattle, Bellevue, Kirkland, Redmond, Renton, Tukwila, Kent Valley
- Less severe to north and south



Fire Station Damage Projections

Table 6-2: Projected Damage to Fire Stations

| Peak Ground Acceleration | % of Stations with Reduced Functionality | % of Stations Not Useable |
|---------------------------------|---|----------------------------------|
| Greater than 0.75g | More than 70% | 20% to 30% |
| Between 0.45g and 0.75g | 60% to 70% | 10% to 20% |
| Between 0.30g and 0.45g | 30% to 40% | Less than 10% |
| Between 0.15g and 0.30g | 10% to 20% | Less than 5% |
| Less than 0.15g | Less than 10% | 0% |



Fire Station Impacts and Recovery Issues

- Units temporarily unavailable while personnel extricate apparatus from station.
- Some units unavailable due to damage to apparatus.
- Some stations may be abandoned due to the extent of damage. This represents an operational challenge after about 24 hours since duty personnel will no longer have sleeping facilities.



Fire Stations Impacts and Recovery Issues

- Is dispatch/communication system operational?
- Large call volume, overwhelming available resources.
- Inadequate water supply inhibiting suppression.
- Delayed responses in some areas due to obstructions in roads, possible bridges and overpasses unusable.



Fire Stations Impacts and Recovery Issues

- Some units will be “homeless”.
- Temporary quarters must be within reasonable response time.
- Use of portable trailers for temporary quarters?

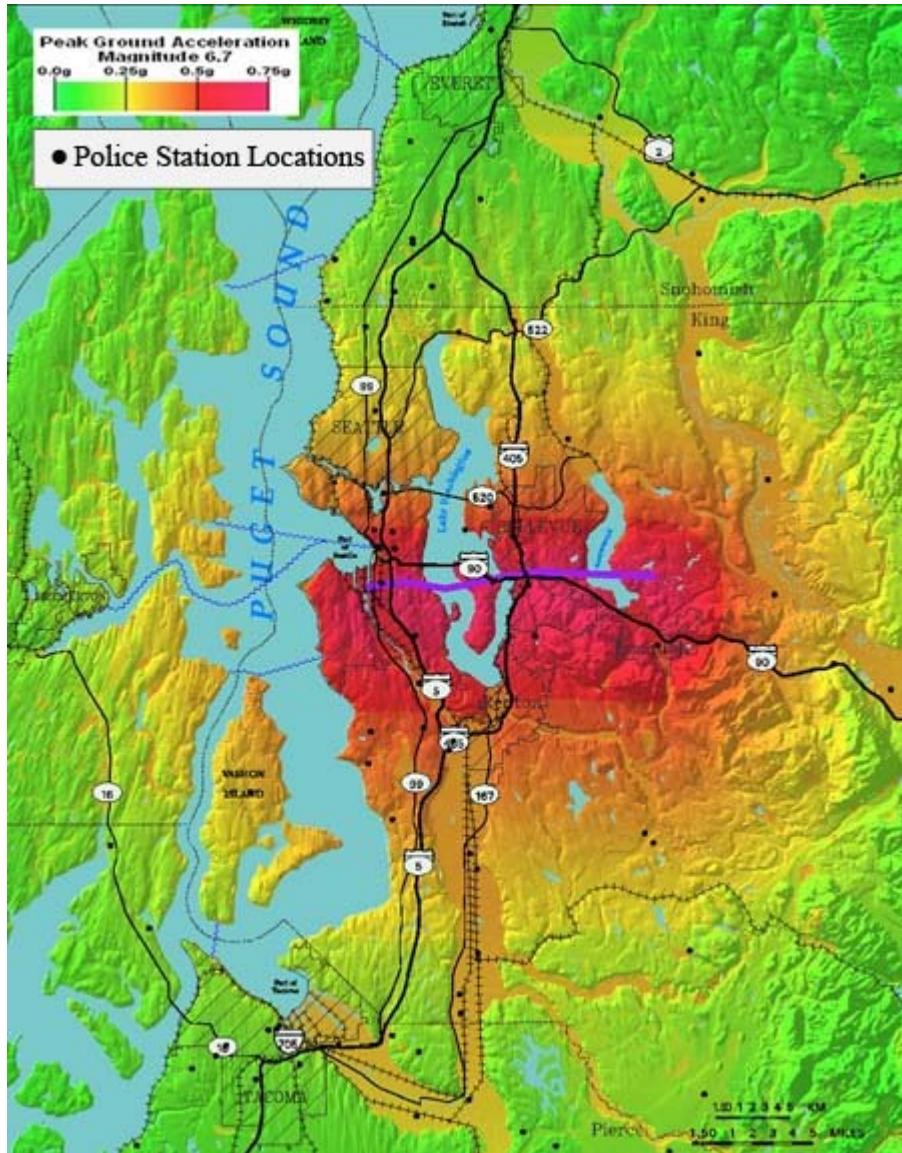


Fire Station Recommendations

- Evaluate all facilities to identify relative risks.
- Emphasis on apparatus bays.
- Non-structural upgrades to reduce injuries and damage to apparatus.
- Possible upgrade of key fire stations to act as post-earthquake response centers.



Overview of Police Stations



- Over 90 police stations in region
- Relatively modern construction
- Communication centers typically not in high risk buildings



Overview of Police Stations

- Some buildings seismically retrofitted - Seattle East Police Precinct.
- King County Sheriff communications center in "hardened" and redundant building.
- City of Seattle Police Department headquarters built in 2002.
- City of Seattle Police Department SW Precinct headquarters - designed as "essential facility".
- Some police stations located in other buildings such as city halls - not typically designed as an "essential facility".



Police Station Performance in Past EQ's

- No impairment of police department response noted in past Puget Sound earthquakes due to building performance.
- Ground motions in Seattle Fault Scenario significantly greater than past Puget Sound events.



Police Station Damage Projections

- Damage to most police stations is not expected to be severe.
- Damage with the largest impact will be non-structural.
- Damage to transportation systems is key for response.



Police Impacts and Recovery Issues

- Not heavily dependent on physical buildings - rely on vehicle based officers in the field.
- Communications are key - dispatch and 911 centers generally not in high risk buildings.
- Performance of transportation infrastructure is important.
- Storage and parking facilities may be damaged - cars and supplies trapped.

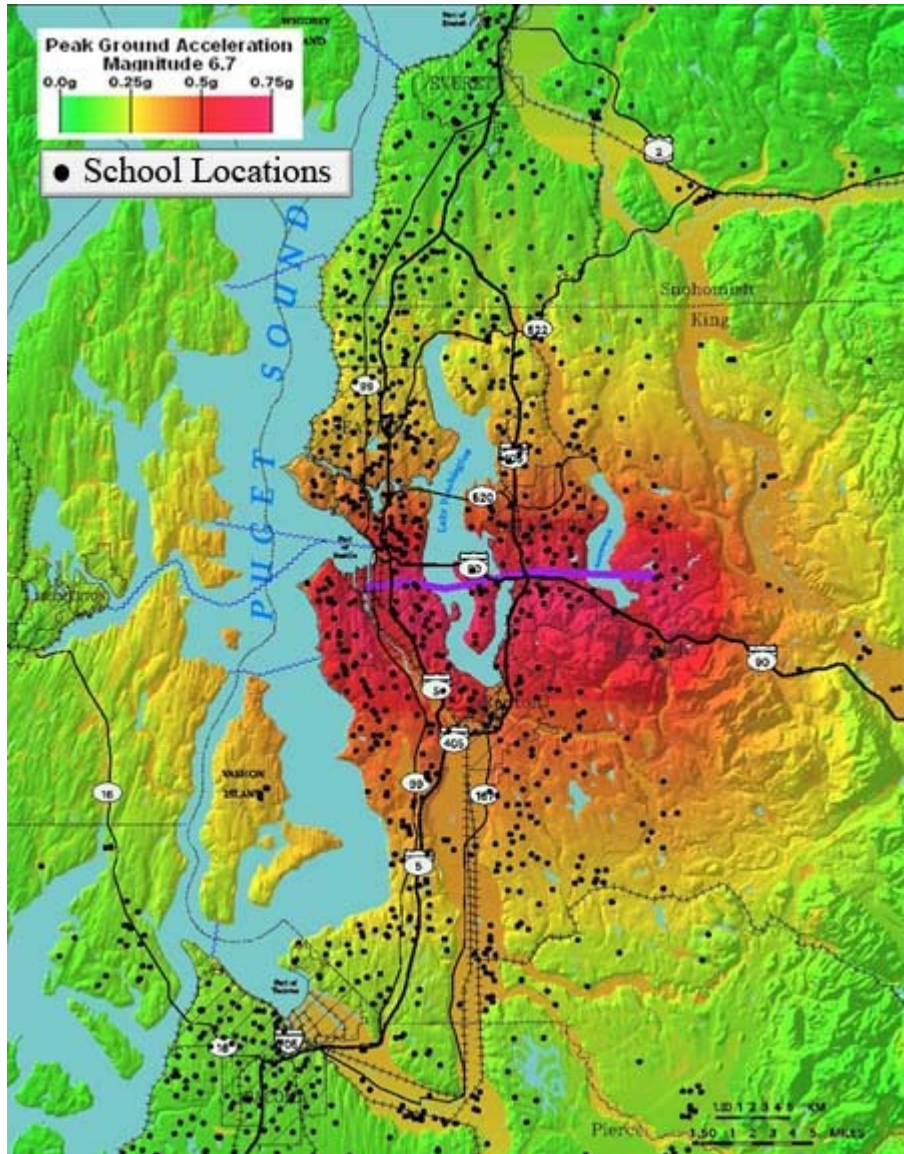


Police Station Recommendations

- Areas of major damage identified quickly so resources can be redirected.
- Police must assess their buildings for both structural and non-structural impacts.
- Communication is key in mobilizing response. This must be assessed in more detail.



Overview of Schools



- Over 1,200 schools and campuses in region
- Wide range of construction materials and age
- Some level of upgrade completed but not well documented as a region



Schools Performance in Past EQ's

- Poor past performance most predominant in unreinforced masonry structures.
- Building codes have progressed in ability to protect schools - have not required strengthening of existing buildings.
- Some level of voluntary strengthening has been undertaken; however, not enough and full extent not well published.



School Damage Projections

Table 6-3: Expected Damage to Schools

| County | Damage (in percent) | | | | |
|--------------|---------------------|--------|----------|-----------|----------|
| | No Damage | Slight | Moderate | Extensive | Complete |
| King County | 23% | 22% | 29% | 18% | 8% |
| Pierce | 64% | 18% | 12% | 5% | 1% |
| Snohomish | 64% | 14% | 9% | 3% | 10% |
| Total Region | 38% | 20% | 22% | 13% | 7% |



School Impacts and Recovery Issues

- Immediate issue of how to care for thousands of children while parents try to reach them.
- Intermediate and long-term issues with where to house students to continue education and allow parents to return to work.
- Local governments may place a higher priority on repair of schools.





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