JUSTIFICATION AND COST-BENEFIT ANALYSIS

OF

RECOMMENDATIONS TO REDUCE EARTHQUAKE LOSSES

for the

UTAH ADVISORY COUNCIL FOR INTERGOVERNMENTAL RELATIONS

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At the request of the Utah Council for Intergovernmental Relations and Steve Klass, Governor's Office of Planning and Budget, we have compiled justification and cost figures for the earthquake hazards reduction activities listed in our memo to the Council, presented at the June 31, 1989, meeting. The Council was particularly interested in the first eight items in List 1, and these are discussed in the following sections in the same order they occurred on our original list. A summary table of costs is included at the back. Costs for recommendations 2,4,5,6, and 8 are very rough estimates based on readily available information and many assumptions, and they are provided only for use by the Council for general assessment of actions to be taken.

Chairman:
Bruce Darley
Mayor of Hyrum

1. Require all new school construction to conform to modern seismic building codes and require inspection during construction by local government building inspectors.

Problem: School buildings are critical facilities which must protect occupants during an earthquake and be an asset to the community for refuge, housing, and relief efforts following an earthquake. At present, new schools are subject to the seismic portions of the Uniform Building Code, but it is not known how rigorously these regulations are enforced. Schools are inspected by school district inspectors for whom there are no minimum qualifications or licensing. Schools do not fall under the jurisdiction of local government inspectors, so there is no assurance that they are inspected by qualified independent inspectors not subject to pressure from building owners (school districts).

Solution: Enforce existing UBC seismic regulations to ensure that new school buildings meet modern seismic building codes and are inspected by qualified, independent inspectors.

Benefit: Benefits include: 1) increased safety for occupants during an earthquake, 2) increased likelihood of building survival for use in relief efforts after an earthquake, 3) decreased liability of government (school districts) for damages and deaths, and 4) decreased community disruption due to long-term post-earthquake closure of schools for repair or reconstruction. The number of deaths and injuries that this will prevent, or the reduction in costs to repair earthquake damage, cannot be estimated at this time. At peak attendance, schools in Utah house about 460,000 students, teachers, and staff that are potentially at risk.

Cost: <u>No additional cost. This problem has already been addressed by passage of the Uniform Building Standards Act</u> during the 1989 legislative session (SB 190, UCA 58-54-9-1), which adopted the 1988 Uniform Building Code and set up a 1 percent surcharge on building permits to fund training and licensing of school and local government inspectors by the State, with the State licensing procedure in place by 1993.

Recommended Council Action: <u>No specific action is required,</u> except to support strict enforcement of seismic building codes and licensing requirements adopted by the State. The parts of this recommendation regarding inspections has been largely addressed by actions already taken by the legislature, except for the potential problem of whether it is <u>advisable to have independent inspections by non-school board employed inspectors.</u>

2. Mandate seismic safety evaluations of existing government buildings, including schools and health-care facilities, and develop a plan to retrofit or retire unsafe buildings.

Problem: Many unsafe government buildings are present which pose a danger to life and property and create liability for government in the event of a damaging earthquake. Many of these buildings are high-occupancy critical facilities that must survive an earthquake to provide services to quake victims.

Solution: Fund the studies necessary to identify unsafe government buildings and develop a cost-effective plan to manage the risk posed by them.

Benefit: A 1986 study (Taylor, 1986) of damage and life loss in state-owned buildings in a high-risk area of Utah (Salt Lake County) estimated potential losses at $260 million (structure and contents), with a potential life loss of over 1200. Seismic retrofit of buildings will result in increased safety for occupants during an earthquake, increased likelihood of building survival with minimal damage for use in relief efforts after an earthquake, decreased liability of government for damages and deaths, and decreased community disruption due to long-term post-earthquake repair and reconstruction.

Factors which make conducting vulnerability studies and establishing seismic retrofit plans feasible and relatively straightforward in Utah which should be considered are: 1) Utah now has the geologic data necessary to make such evaluations more accurately than anywhere outside of California, and 2) the Federal Emergency Management Agency, the Applied Technology Council, and the Building Seismic Safety Council, among others, have several recent professional handbooks with methodology for conducting such an assessment, including: "An Action Plan for Reducing Earthquake Hazards of Existing Buildings", "A Methodology for the Seismic Evaluation of Existing Buildings", and "Establishing Priorities for the Seismic Rehabilitation of Buildings."

Cost: This element seeks to mandate the evaluation (earthquake vulnerability assessment) of existing structures. This evaluation would be the first step in a cost/benefit analysis of seismically retrofitting state-owned buildings. Without the primary results of a vulnerability assessment, no detailed prioritization, feasibility, or long-term work plan can accurately be constructed.

The evaluation or assessment of buildings is very low-cost in comparison to an actual retrofit program. As an example, there have been at least two recent, separate seismic assessments of public buildings in Utah. The first study, completed in 1987, assessed all 40 schools, the administration building, and the maintenance shop of the Salt Lake City School District. The assessment of these structures included a vulnerability rating, recommendations, and costs for retrofitting individual structures. The total cost to the school district for contracting this vulnerability assessment on 42 buildings was $43,000, with an average cost per building of about $1,000. Six of the school buildings were rated as seismically "good", requiring no spending for retrofit. These schools were recently built under a code which includes some earthquake resistant design. If the assumption can be made that most new structures may not require retrofit, they could be excluded from the initial assessment. The other study was conducted on all critical buildings belonging to Salt Lake City Corporation. This vulnerability assessment and retrofit cost estimation looked at 10 fire stations, 4 water treatment facilities, 2 water reclamation plants, and 4 fleet management buildings for a total of 20 separate sites, of which at least 4 are large complex facilities. Total cost for this assessment was $100,090 or about $5,000 per facility.

This type of evaluation not only provides a technical look at the vulnerability of individual structures, but provides detailed information about possible future dollar loss and more importantly, risk to human life. These studies also provide a starting point for a realistic look at what should be done with different structures on a short and long-term basis. Such data can be included in master plans, modernization/remodel plans, emergency or disaster plans, and risk management evaluations, and used to make general assumptions about the vulnerability of buildings that have not been analyzed.

In order to make some rough estimates of what it would cost to evaluate state-owned buildings, and then a very rough estimate of possible retrofit costs, some extrapolations of the above studies and one other earthquake loss study can be employed. To date there has not been a state-wide or even total Wasatch Front evaluation of retrofit costs for state-owned buildings. To make such an assessment and prioritize the retrofit program, five variables must be analyzed:

1. Number of buildings owned by the State.
2. Location of each building.
3. Building use.
4. Building type and age.
5. Number of square feet necessary to retrofit or bring up to code.

From these basic criteria the general retrofit costs in a high vulnerability area can be estimated by building type. The sum of these costs gives the total retrofit estimate.

As a rough estimate of the cost to perform a vulnerability analysis of state-owned buildings in the high-risk area (Salt Lake County), the data from a 1986 earthquake loss estimation study (Taylor, 1986) can be examined together with the costs of the two completed vulnerability reports. The Taylor data includes all (191) state-owned buildings in Salt Lake County, mostly University of Utah structures including the University

Hospital (fig. 1). The buildings were put into three classes based on building type/construction, and hence estimated earthquake damage potential: 1) high damage, 2) moderate to high damage, and 3) low damage. If those with low damage are eliminated as probably not requiring retrofit, and therefore no initial assessment, the number of structures goes from 191 to 116 (table 1). In discussions with the contractor who performed these studies, the Salt Lake City School District study was under bid and the cost per building was low by a factor of 3-4 compared to the actual cost. The average cost per building for the Salt Lake City Corporation study was high because it included complex water treatment plant buildings. Based on this information, the cost of an assessment on a large building can be generalized to be about $4,000, yielding a total cost of vulnerability assessment of all high-risk state buildings in Salt Lake County of approximately $464,000.

A further extrapolation would give some rough figure of the total cost for retrofit of the same 116 structures. This figure will be subject to a large error because square footages for each building type (variable 4 and 5) have not been calculated for building class. The total cost for retrofitting 36 SLC schools was estimated at $30 million - an average of $833,333 per school building. The cost for upgrading 10 Salt Lake City fire stations was estimated at $1.36 million or about $136,000 per station. The fire stations are obviously smaller, less complex structures than the schools.

Assuming that most of the state-owned buildings in Salt Lake County are closer in structural type and square footage to the schools than to the fire stations (most structures are university buildings), a factor of .85 could be applied to the school average - giving a figure of $712,500 per building. An inventory of 116 buildings would require retrofit costs of about $83 million. The average cost per square foot for retrofit of the school buildings is $8.75, with a high of about $18.00. If the average floor space of the state-owned buildings is 81,400 sq. ft., then this is a ball park figure.

Compare these costs with the Taylor study loss figures of $260 million for the same buildings, combined with potential life-loss of over 1200, and lost function for an extended period (table 2,3, and 4), and the cost/benefit ratio quantitatively and qualitatively goes down, especially if the retrofit program is implemented into other short and long-term state facility improvement plans.

These costs are for state-owned buildings in Salt Lake County only. We do not have the necessary data statewide to estimate costs, but it is likely that the probable costs for all state-owned buildings in high-risk seismic areas would be over $1 million for vulnerability studies, and several hundred million dollars for seismic retrofit.

Recommended Council Action: Recommend that the State, local governments, and school districts begin funding the vulnerability studies and establish plans to manage risks.

BLD.	FACILITY NAME
1	DOT DIST 2 ROAD SHED(2010/232)
2	DOT DIST 2 ROAD SHED(2011/231)
3	STATE JUVENILE COURT(2077/001)
4	DNR ADMINISTRATION(2082/005)
5	DOT DIST 7 ROAD SHED(2087/234)
6	UNG ARMORY(2088/001)
7	UNG ARMORY(2088/002)
8	UNG EVACUATION HOSP(2088/003)
9	UNG MAINT BLDG SUB(2088/004)
10	UNG MAINT BLDG(2088/005)
11	NAT GUARD MAINT SHOP(2088/006)
12	NATL GUARD USP & FO(2088/007)
13	DRIVERS LICENSE DIV(2225/001)
14	DCED UT NAT AMERICAN(2324/001)
15	LCC WAREHOUSE/OFF(2325/001)
16	AGRICULTURE DEPT OFF(2332/001)
17	DFCM HM WELLS BLDG(2335/001)
18	GOVERNOR'S MANSION(2337/001)
19	LCC RETAIL STORE(2339/001)
20	UU PARK BLDG(3000/001)
21	UU BALLET STUDIO(3000/002)
22	UU GARDNER HALL(3000/003)
23	UU KINGSBURY HALL(3000/004)
24	UUGEORGE THOMAS BLDG(3000/005)
25	UU WM STEWART BLDG(3000/006)
26	UU LIFE SCIENCE BLDG(3000/007)
27	UU EMERY/HOME EC(3000/008)
28	UU JOHN WIDTSOE BLDG(3000/009)
29	UU PHYSICS BLDG(3000/010)
30	UU BROWNING MINERALS(3000/011)
31	UUCOWLES COMMUNICATN(3000/013)
32	UU TALMADGE BLDG(3000/014)
33	UU DANCE BLDG(3000/015)
34	UU SEISMOGRAPH BLDG(3000/016)
35	UU GEOLOGY BLDG(3000/017)
36	UU STORAGE BLDG(3000/019)
37	UU CERAMIC ENG(3000/020)
38	UU APPLIED RESEARCH(3000/021)
39	UU MATERIAL SCI LAB(3000/022)
40	UU MILITARY SCI BLDG(3000/023)
41	UU MINES BLDG(3000/024)
42	UU SOC-BEHAV BLDGS(3000/025)
43	UU NEILSEN FIELDHSE(3000/029)
44	UU CARLSON HALL(3000/031)
45	UU STADIUM(3000/032)
46	UU FINE ART MUSEUM(3000/036)
47	UU ART/ARCHITECHTURE(3000/037)
48	UU ORE DRESSING LAB(3000/042)
49	UU NAVAL SCIENCE(3000/043)
50	UU STUDENT HEALTH(3000/044)
51	UU SERVICES(3000/050)
52	UU SILL LIVING CNTR(3000/051)
53	UU ALUMNI HOUSE(3000/052)
54	UU OLPIN UNION BLDG(3000/053)
55	UU SPENCER HALL(3000/054)
56	UU BALLIF HALL(3000/055)
57	UU MERRILL ENGINEER(3000/064)
58	UU BENNION HALL(3000/065)
59	UU PIONEER MEM THTR(3000/066)
60	UU BOOKSTORE(3000/067)
61	UU VAN COTT HALL(3000/068)
62	UU HI TEMP HEAT PLNT(3000/069)
63	UU LAW LIBRARY(3000/072)
64	UU LAW BLDG(3000/073)
65	UU BUSINESS BLDGS(3000/074)
66	UU ACCELERATOR(3000/078)
67	UU SPACE MGMT(3000/080)
68	UU AUSTIN HALL(3000/081)
69	UU SKAGGS PHARMACY(3000/082)
70	UU FLETCHER PHYSICS(3000/083)
71	UU BIOLOGY BLDG(3000/084)
72	UU EYRING CHEMISTRY(3000/085)
73	UU MARRIOTT LIBRARY(3000/086)
74	UU VIVARIUM BLDG(3000/087)
75	UU COLL NURSING(3000/088)
76	UU ECCLES MED LIBR(3000/089)
77	UU SPECIAL EVENTS(3000/090)
78	UU H P E R(3000/091)
79	UU FAMILY/COMM MED(3000/100)
80	UU TANNER DANCE(3000/101)
81	UU PHYSICAL THERAPY(3000/102)
82	UU ANNEX BLDG(3000/105)
83	UU BLDG(3000/122)
84	UU TEMP OFF BLDG(3000/123)
85	UU BLDG(3000/124)
86	UU MATH TUTORIAL(3000/129)
87	UU ALUMNI OFFICE(3000/134)
88	UU DPT OF PUB SAFETY(3000/301)
89	UU PHYS PLANT STOR(3000/304)
90	UU PLANT OPERATIONS(3000/305)
91	UU GENERAL SERVICES(3000/306)
92	UU MOTOR POOL BLDG(3000/309)
93	UU PHYS PL SERV STA(3000/317)
94	UU GREENHOUSE(3000/320)
95	UU ARBORETM GREENHSE(3000/329)
96	UU PUMPHOUSE 1(3000/331)

State-Owned Buildings Surveyed (Page 1 of 2)

Figure 1

BLD.	FACILITY NAME
97	UU PUMPHOUSE 2(3000/332)
98	UU PUMPHOUSE 3(3000/333)
99	UU PUMPHOUSE 4(3000/334)
100	UU PUMPHOUSE 5(3000/335)
101	UU PUMPHOUSE 6(3000/336)
102	UU STEAM GEN PLNT(3000/347)
103	UU ACV STOR HUT(3000/348)
104	UU ACV TRANSFORMER(3000/349)
105	UU FIRE STATION(3000/378)
106	CHEM/ENG RES(3000/391)
107	UU GROSS ANATOMY(3000/402)
108	UU PSYCHOLOGY RES(3000/404)
109	UU HOSP ENG STOR(3000/406)
110	UU PHYS PLANT STOR(3000/407)
111	UU STANGL BLDG(3000/410)
112	UU MIDDLE EAST CTR(3000/413)
113	UU PARKING SERV(3000/416)
114	UU SURGERY PATHOLOGY(3000/419)
115	UU OUTDOOR REC(3000/420)
116	UU COLL OF MEDICINE(3000/428)
117	UU STORAGE BLDG(3000/430)
118	UU ATHLETICS(3000/435)
119	UU MED CTR ARCHITECT(3000/436)
120	UU PROP REDISTRIB(3000/437)
121	UU NEUROLOGY RADIOLO(3000/453)
122	UU RADIOLOGIC HEALTH(3000/502)
123	UU OCCUP/ENVIR HEALT(3000/504)
124	UU MICROBIOLOGY RES(3000/507)
125	UU REP DANCE STUDIO(3000/508)
126	UU REP DANCE STUDIO(3000/509)
127	UU VIRUS RES/MICROBI(3000/511)
128	UU INTERNATL HOUSE(3000/512)
129	UU STORAGE BLDG(3000/513)
130	UU PHARMACY STORAGE(3000/514)
131	UU STORES/REC(3000/515)
132	UU RADIOLOGIC HEALTH(3000/516)
133	UU HOSP/ENG MACHINES(3000/517)
134	UU DENTAL ED(3000/518)
135	UU MICROBIOLOGY(3000/519)
136	UU MED CTR STOR(3000/520)
137	UU MEDICAL CENTER(3000/521)
138	UU RADIOLOGY LAB(3000/522)
139	UU MED CTR PARKING(3000/524)
140	UU PATIENT CARE HOSP(3000/525)
141	UU MED CTR GEN PLANT(3000/526)
142	UU WINTROBE RES/ED(3000/530)
143	UU CANCER RES(3000/531)
144	UU E&E DUMKE BLDG(3000/535)

BLD.	FACILITY NAME
145	UU STORAGE BLDG(3000/543)
146	UU ACU PATH INCIN(3000/560)
147	UU CEU SEISMOGRAPH(3000/590)
148	OLD ST MARKS HOSP(3000/595)
149	UU PRESIDENTS HOME(3000/598)
150	UU MED STUDENT HSE 1(3000/701)
151	UU MRD STU HSE OFF(3000/722)
152	UU UNIV VILLAGE(3000/724)
153	UU UNIV VILLAGE N(3000/746)
154	UU UNIV VILLAGE N(3000/761)
155	UTC HEATING PLANT(3007/001)
156	UTC ADMIN BLDG(3007/002)
157	UTC METAL TRADES(3007/003)
158	UTC AUTOMOTIVE BLDG(3007/004)
159	UTC TECHNOLOGY BLDG(3007/005)
160	UTC STUDENT UNION(3007/006)
161	UTC LABOR TRAINING(3007/007)
162	UTC CONSTRUC TRADE(3007/008)
163	UTC RESIDEN/ART LAB(3007/009)
164	UTC MAIN BLDG(3010/00A)
165	UTC AUTO PAINT STOR(3010/00B)
166	FAIR UT POWER LT(8006/007)
167	FAIR CATTLE BLDG(8006/008)
168	FAIR CATTLE BLDG(8006/009)
169	FAIR CATTLE BLDG(8006/010)
170	FAIR SHEEP BLDG(8006/011)
171	FAIR COMM EXHIBIT(8006/013)
172	FAIR COLISEUM(8006/014)
173	FAIR CRAFT&PHOTO(8006/018)
174	FAIR REFRESHMT&RR(8006/019)
175	FAIR FLOWER BLDG(8006/022)
176	FAIR COMM EXHIBIT(8006/023)
177	FAIR HORTICULTURE(8006/024)
178	FAIR HOME ARTS(8006/026)
179	FAIR GRANDSTAND(8006/030)
180	FAIR INDUSTRIAL(8006/032)
181	FAIR PIGEON-POULT(8006/037)
182	FAIR GRANDSTAND(8006/040)
183	DPS DRIVERS LIC DIV(8006/201)
184	STATE CAPITOL(8008/001)
185	STATE OFF BLDG(8008/002)
186	DFCM ARCHIVES OFF(8008/003)
187	COUNCIL HALL(8008/006)
188	PIONEER MEM MUSEUM(8008/007)
189	GOV CARRIAGE HSE(8008/009)
190	PLAZA SERV STA/CAF(8008/010)
191	WHITE CHAPEL(8008/013)
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State-Owned Buildings Surveyed (Page 2 of 2)

Figure 1

Factors and Assumptions Affecting Casualty and Loss Estimates for State-Owned Buildings and from a 7.3 Magnitude Earthquake on the Salt Lake Segment, Wasatch Fault Zone

MICROZONE	(CALCULATED) MAXIMUM POPULATION ASSUMED*	RATIO IN Q = 1 BUILDINGS	RATIO IN Q = 2 BUILDINGS	RATIO IN Q = 3 BUILDINGS	NUMBER OF BUILDINGS WITH SQUARE FOOTAGE DATA	DYNAMIC AMPLIFICATION FACTOR (ROGERS, ET AL. 1984)	ESTIMATED DISTANCE ABOVE OR TO SEISMOGENIC PLANES** (MILES)	CALCULATED MM INTENSITY (SHAKING)	MMI INTENSITY WITHOUT AMPLIFICATION
T1NR1WS34	829	.00	.52	.48	3	6.2	3.8	10.43	8.27
T1NR1WS35	1315	.96	.04	.00	17	6.2	3.1	10.57	8.42
T1NR1WS36	258	.89	.11	.00	2	3.7	≤3.1	9.96	8.42
T1NR1ES31	3517	.80	.20	.00	5	3.7	≤3.1	9.96	8.42
T1SR1ES6	638	.40	.40	.20	2	6.2	≤3.1	10.58	8.42
T1SR1ES4	45302	.06	.23	.71	85	2.7	≤3.1	9.59	8.42
T1SR1ES3	1577	.00	.14	.86	3	6.2	≤3.1	10.58	8.42
T1SR1WS12	99	1.00	.00	.00	1	6.2	≤3.1	10.58	8.42
T1SR1ES8	0	-	-	-	0	6.2	≤3.1	10.58	8.42
T1SR1ES9	2548	.21	.22	.57	5	3.7	≤3.1	9.96	8.42
T1SR1WS14	0	-	-	-	0	6.2	≤3.1	10.58	8.42
T1SR1WS35	216	.50	.50	.00	1	6.2	4.8	10.24	7.95
T2SR1WS4	63	.50	.50	.00	1	6.2	7.0	9.89	7.73
T2SR1WS3	5328	.00	.08	.92	8	6.2	3.2	10.56	8.40
T2SR1WS8	27	.00	.50	.50	1	6.2	8.4	9.70	7.54
T2SR1WS13	0	-	-	-	0	6.2	≤3.1	10.58	8.42
T2SR1WS30	0	-	-	-	0	6.2	5.6	10.10	7.94
TOTAL	61,377	.13	.21	.66	134				

*BASED ON ONE PERSON PER 150 GROSS SQUARE FOOT (IF SQUARE FOOTAGE DATA ARE AVAILABLE). THIS COLUMN AFFECTS TOTAL CASUALTY ESTIMATES, AND ALSO TOTAL CASUALTY RATIOS FOR ALL STATE-OWNED BUILDINGS. POPULATION IN THESE BUILDINGS, HOWEVER, VARIES ENORMOUSLY ACCORDING TO TIME-OF-DAY, DAY OF THE WEEK, ETC.

**EACH ZONE IN THIS LIST IS ASSUMED EITHER TO BE NORMAL TO A SPECIFIC FAULT PLANE, OR ELSE TO BE TO THE EAST OF THE WASATCH FAULT ZONE. SHORTER DISTANCES ARE OFTEN DERIVABLE IF THE DISTANCE TO ANY FAULT PLANE IS ESTIMATED. FIGURE 4-1 SHOWS ESTIMATED DISTANCES TO ANY FAULT PLANE.

Table 1

Table 2

Mean Building Loss, Contents Loss, and Downtime Estimates to State-Owned Buildings in Event Number 1 (7.3 Ms) on the Salt Lake Segment of the Wasatch Fault Zone

	BUILDING LOSS ($K)			CONTENTS LOSS ($K)			DOWNTIME (YEARS)		
MICROZONE	Q = 1	Q = 2	Q = 3	Q = 1	Q = 2	Q = 3	Q = 1	Q = 2	Q = 3
T1NR1W§34	0	2,595	1,008	0	468	178	0	.41	.09
T1NR1W§35	4,573	140	0	48	0	0	.66	.66	0
T1NR1W§36	2,636	88	0	1,884	0	0	.66	.30	0
T1NR1W§31	53,056	3,188	0	5,378	735	0	.66	.32	0
T1SR1E§6	3,276	3,120	4,329	432	432	2,286	.66	.66	.11
T1SR1E§4	46,380	24,899	16,779	9,205	25,252	19,010	.66	.29	.05
T1SR1E§3	196	3,179	1,175	12	20	3	.66	.66	.09
T1SR1W§12	467	0	0	0	0	0	.66	0	0
T1SR1E§8	5	0	0	0	0	0	.66	0	0
T1SR1E§9	2,906	1,085	1,017	18	200	253	.66	.31	.06
T1SR1E§14	0	0	575	0	0	2,805	0	0	.33
T1SR1W§35	843	346	0	93	76	0	.66	.37	0
T2SR1W§4	192	57	0	22	13	0	.66	.30	0
T2SR1W§3	0	2,577	6,571	0	236	2,942	0	.66	.11
T2SR1W§8	0	25	11	0	10	4	0	.12	.04
T2SR1W§13	157	157	0	5	5	0	.66	.66	0
T2SR1W§30	0	56	0	0	6	0	0	.33	0
TOTALS	114,687	41,512	31,465	17,097	27,453	27,481			
GRAND TOTALS ($K)	$187,664			$ 72,031					

Table 3

(Mean) Ratios of Deaths and Injuries to Exposures in State-Owned Buildings for a 7.3 Ms Event on the Salt Lake Segment of the Wasatch Fault Zone

MICROZONE	RATIO DEAD	RATIO SEVERELY INJURED	RATIO MODERATELY INJURED
T1NR1W§34	.03	.07	.11
T1NR1W§35	.19	.15	.13
T1NR1W§36	.18	.15	.13
T1NR1E§31	.16	.14	.13
T1SR1E§6	.11	.12	.13
T1SR1E§4	.01	.03	.09
T1SR1E§3	.01	.04	.12
T1SR1W§12	.20	.16	.13
T1SR1E§8	-	-	-
T1SR1E§9	.05	.06	.11
T1SR1W§14	-	-	-
T1SR1W§35	.12	.13	.13
T2SR1W§4	.11	.11	.12
T2SR1W§3	.01	.05	.13
T2SR1W§8	.005	.03	.10
T2SR1W§13	-	-	-
T2SR1W§30	-	-	-
TOTALS	.03*	.04*	.10*

*THESE DEPEND HEAVILY ON POPULATION EXPOSURE ASSUMPTIONS IN TABLE 4-1. ALTERNATIVE EXPOSURE ASSUMPTIONS CAN BE MADE FOR EACH MICROZONE. THESE, ALONG WITH THE ABOVE RATIOS, CAN BE USED TO APPROXIMATE EXPECTED CASUALTIES IN STATE-OWNED BUILDINGS

Table 4

Casualty Ratios in Different Seismic Quality Classes of Construction* for State-Owned Buildings Affected by a 7.3 Ms Earthquake on the Salt Lake Segment of the Wasatch Fault System

	RATIO DEAD	RATIO SEVERELY INJURED	RATIO MODERATELY INJURED
Q = 1	.20	.16	.13
Q = 2	.02	.05	.11
Q = 3	.0008	.01	.06

*THESE RATIOS APPLY ONLY GIVEN EXPOSURE ASSUMPTIONS IN TABLE 1

REFERENCES

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3. Provide for geologic hazards evaluations of proposed sites for new government buildings or government-funded construction prior to site selection and design.

Problem: Government buildings are still being sited in hazardous areas, sometimes with no knowledge of the hazards and sometimes with knowledge coming too late in the process, making it difficult and expensive to abandon sites or alter designs.

Solution: Perform geologic hazards evaluations of sites when proposed, not after they have been selected, purchased, and designed. For buildings administered by DFCM, this problem has been largely solved by a recent revision of their RFP for geotechnical investigations to include more geologic hazards information. This information is generally for sites already chosen, but DFCM has little flexibility in choosing sites and the information is being collected prior to site design.

Benefit: Problem sites which pose a hazard to buildings and occupants and which may be too expensive to develop will be avoided or designed properly, reducing losses and avoiding long-term maintenance expenses. It is not known how many government buildings are presently in geologically hazardous areas, but costly construction delays occurred for the Allied Health Building on the Weber State campus as a result of geologic problems encountered in the excavation, and high maintenance and repair costs have been incurred on the Southern Utah State College and Weber State campuses from foundation problems related to collapsible soils and shallow ground water.

Cost: The UGMS presently performs these evaluations for schools and local government critical facilities at no cost, and can continue to do so as long as the demand does not significantly increase. We do not do them for most State projects because DFCM prefers to use private consultants to limit government liability. The cost of these studies by private consultants is already included in DFCM's budgets for new projects and does not represent an additional cost.

Recommended Council Action: Recommend that a geologic hazards evaluation be required for schools and local government critical facilities, either by UGMS or private consultants. No council action is required for state-owned buildings because studies are already required and paid for under normal procedures.

4. Include geologic hazards elements in local government master plans and/or land-use ordinances.

Problem: Much private development is allowed to proceed with no consideration of geologic hazards, resulting in losses to private citizens and possible increases in government liability for issuing building permits.

Solution: Local governments need to incorporate geologic hazards into their master plans and zoning and land-use ordinances, and provide a mechanism for implementation and enforcement of ordinances by qualified persons.

Benefit: Long-term land-use planning is one of the cheapest and most effective hazard reduction measures. It helps avoid problems before they happen, and requires that hazard reduction measures be planned and in place prior to project completion. Property damage and life loss will be reduced, and possible local government liability for issuing building permits in hazard areas will be avoided. Benefits from such a program would be realized chiefly by property owners, in reduced damages and increased life safety. Damages from geologic hazards, (rise of Great Salt Lake, debris flows in Davis County) in 1983, some of which could have been avoided with proper land use through local government ordinances, totaled several hundred thousand dollars.

Cost: The major cost to government to pass an ordinance is staff time to prepare it. Model ordinances are now available, but the staff time required is too variable to predict. However, such activities are a normal part of a planning department's duties and thus do not represent an additional cost. The cost of geologic hazard site-investigation reports required by such an ordinance is paid by the developer, and these costs are generally about $1,000 per project, but may range up to 3,000 in particularly hazardous areas and where little existing information is available. At present construction rates, it is estimated that Wasatch Front counties (Utah, Salt Lake, Weber, Davis) will receive about 150 such reports per year in response to such ordinances. Construction rates are generally lower outside the Wasatch Front, and we estimate a total cost to developers for such studies statewide to be in the range of $250,000 to $300,000 per year (assuming 250 such studies/year).

Recommended Council Action: Recommend that local governments develop and adopt the needed ordinances, or that the State pass legislation to require them by all local governments.

5. Adopt Uniform Building Code (UBC) appendices which include provisions for strong-motion instrumentation in buildings.

Problem: In order to learn from an earthquake and document its effects so that seismic inadequacies in building design will not be repeated, the response of buildings to ground shaking must be documented and patterns of failure understood. A means is also needed to assist structural engineers in assessing building safety following an earthquake. Instrumental recordings are the best way for structural and earthquake engineers to learn how a building responds to ground shaking, and what modifications are needed for new and existing buildings to improve earthquake performance. The lack of strong-motion data in Utah has made it very difficult to know how buildings will respond to earthquake shaking, and this confusion makes it difficult to know what action should be taken in terms of building design. At present, buildings are insufficiently instrumented to provide the needed data.

Solution: Require that instruments be placed in certain new buildings and in some existing buildings to document building response to ground shaking. This can be done through adoption of UBC Appendix Chapter 23, Division II-Earthquake Recording Instrumentation, by the State. This chapter requires instruments in certain new buildings and requires that space be made available for instruments in existing buildings. Experience in California has indicated that the number of instruments required by the UBC in each building (three in each building of 60,000 square feet over 6 stories and all buildings over 10 stories) may be reduced and still record valuable information for post-earthquake damage studies. <u>Salt Lake County has already adopted this UBC Appendix Chapter.</u>

Benefit: Benefits will include long-term reductions in damage and life loss in tall buildings, and much-needed new information on building response to ground shaking. <u>It would also provide government the authority to place instruments in buildings as needed under item 7 below.</u> The City-County Building now contains strong-motion instruments strategically located to provide the needed information on performance of the base-isolation system during an earthquake.

Cost: Strong-motion instrumentation of a new building costs about $50,000, which would be <u>paid by the building owner.</u> There is <u>at most 1 building/year constructed in Utah of sufficient size to be covered under UBC Appendix Chapter 23, for a total annual cost to building owners of $50,000.</u> Instrumentation of existing buildings would cost the same, but would be paid by government. These costs are covered under item 7 below.

Recommended Council Action: <u>Recommend adoption of UBC Appendix</u>

Chapter 23, Division II, by the State.

6. Require disclosure of geologic hazards information in real estate transactions.

Problem: Many homes have been built in hazard areas, and there is presently no way to inform potential buyers of the risks they may be incurring by buying a property.

Solution: Require that geologic hazards information be disclosed to buyers prior to closing real estate transactions.

Benefit: Different buyers are willing to accept different risks, and this will ensure that all buyers have the information needed to make informed decisions, taking all potential risks into consideration. It will make hazard areas less attractive to buyers and builders unless hazards can be reduced to an acceptable level.

Cost: There are many ways to enact disclosure. As envisioned by UGMS, most costs would by incurred by County government to get hazards information into their data base and make it available to real estate agents and prospective buyers when they do a title/deed search. The geologic information is presently being prepared by UGMS and Wasatch Front County Geologists, so this does not represent an additional cost. For the County, additional costs would be in staff time to input data into a computerized or other data base compatible with other plat information. In Salt Lake County, it is estimated that this will take about 4 months staff time for a computer technician, or about $20,000. We assume it would cost the other four most populous Wasatch Front Counties where similar detailed information is available about the same for a total of $100,000. For the remainder of the State, less information is available and computer systems are less common, so costs would presumably be much less. A total statewide cost to counties should be less than $200,000.

Recommended Council Action: Recommend that the State require disclosure of geologic hazards in real estate transactions.

7. Modernize seismographic instrumentation operated by the University of Utah Seismograph Stations to meet State needs, and expand instrumentation to address needs of the engineering community for strong-motion information and public-safety officials for emergency response.

Problem: More complete and better technical information is needed to provide the basis for various earthquake hazard reduction strategies, including proper siting and construction practices and effective emergency preparedness, and for accurate risk assessment. The information must be specific to Utah, and can only be collected with sophisticated instruments at strategic locations throughout the state. Existing earthquake-related instrumentation in Utah is out-of-date and/or seriously inadequate for meeting the State's needs for earthquake monitoring, research, hazard identification and mitigation, earthquake engineering, risk and crisis management, emergency response, and public safety.

Solution: Fund acquisition, deployment, and maintenance of the necessary instrumentation. The UGMS, UUSS, and Utah CEM convened a panel of internationally and nationally prominent seismologists, earthquake engineers, and earthquake policy experts in August to review Utah's earthquake problems and provide the State with an objective view of the need for earthquake-related instrumentation. The panel provided recommendations and estimated costs for the recommended program.

Benefits: The Wasatch Front region may sustain losses from damage to buildings of up to $4.5 billion in a large earthquake in the Salt Lake City area. It is estimated that damage to buildings may represent only about 20 percent of the total cost of a large earthquake, and that State and local governments generally pay for 75 percent of the total economic losses. Life loss would be in the thousands, depending on the time of day that the earthquake occurred. Because of this, long-term hazard reduction strategies are essential to reduce risk. Instrumentation provides much of the data needed to determine the level of hazard for use in assessing risks and setting loss reduction policies.

In addition to reducing losses, instrumentation may potentially provide both savings and earning for the State. Whereas under-design in terms of earthquake-resistant construction may not provide the needed safety, over-design may result in unnecessary expenditures which can be in the multi-million dollar range for single large projects. Accurate hazards assessments allow insurance companies to establish rates in line with the actual risk. When large engineering projects such as the Superconducting Super Collider and various water works (Jordanelle Dam, other CUP components) are planned, earthquake data which cannot be collected over the short-term are needed at once. If Utah is to attract such projects, reliable information must be immediately available for decision-making. Instrumentation is also needed to establish the suitability and provide design criteria for proposed waste disposal projects such as the federal high-level nuclear waste repository in Canyonlands and various waste and weapons disposal projects on Utah's military reservations. An upgraded instrumentation network will not only provide the data needed, but may also help to demonstrate Utah's commitment to and experience with sophisticated technology to support such projects. Finally, it is estimated that investing in such an instrumentation network may provide a 2:1 return in attracting federal and private money for research and implementation and will also help bring top people in related fields to the State and the University of Utah.

Cost: The panel urged that the State invest $2.65 million in a one-time initial cost and $382,000 per year continuing cost to establish a minimal yet effective and adequate program.

Recommended Council Action: Recommend adoption of the panel recommendations in terms of instrumentation needs, and support legislative funding for the program.

8. Set increased individual, student, and teacher earthquake awareness and planning as a State goal.

Problem: Earthquake education is not a part of any present educational curricula, and the public is uninformed with regard to earthquake hazards and preparedness, particularly as it relates to the purchase of a home. Information helps to dispel fear, and also to convince the public of the need for preparedness.

Solution: Institute a program of earthquake education in public schools.

Benefit: An informed public is a better prepared public, and is more likely to support preparedness efforts.

Cost: A program to educate teachers and then to add an earthquake element to physical science curricula, preferably in high school, will be needed. We estimate perhaps a 3-class-period set of lectures will need to be developed, and Utah CEM, UGMS, and the Utah Museum of Natural History (UMNH) are presently working with the State Office of Education to develop this. Teacher training can be done through the Office of Education as part of normal teacher continuing education. Curricula materials can be worked up and workshops for teachers run by Utah CEM, UGMS and UMNH. The principal costs to school districts will be purchase of materials (slide sets and notes, <u>about $100 per school or $10,100 total for all 101 high schools)</u>, and normal costs to teach the material (handouts, about 3 hours class time).

Recommended Council Action: <u>Support incorporation of a natural hazards element in teaching curricula in public schools.</u>

Summary of costs for earthquake (and other geologic) hazards reduction recommendations

Recommendations (see text for complete wording)	Total Statewide Costs to:				
	State	Counties	Cities	School Districts	Private
1. School construction and inspection to meet seismic codes	---	---	---	---	---
2a. Seismic safety evaluations b. Retrofit costs	(Salt Lake County Only) $464,000 $83,000,000 (both one-time initial costs)	-	not determined	-	
3. Geologic hazards evaluations for all new government construction	---	---	---	---	---
4. Geologic hazards elements in local government ordinances	---	---	---	---	$250,000-300,000/yr
5. Adopt UBC appendix for strong-motion instrumentation	---	---	---	---	$50,000/yr
6. Disclosure	---	$200,000 (one-time initial cost)	---	---	---
7. Seismographic and strong-motion instrumentation	$2,650,000 (one-time initial cost) and $382,000/yr	---	---	---	---
8. Education/increased awareness	---	---	---	$10,100	---