approach navigation aids. Airport facilities of the more complex type typically have several runways, runway and taxiway edge lighting, sophisticated complex directional navigation aids, visual, and instrument approach facilities. Two of the project cities, Memphis and Little Rock, have Category II instrument landing systems available at their primary public airports.

Airport facilities in the six cities are estimated to retain partial availability and utility following either of the earthquake scenarios. Terminal buildings, maintenance structures and aircraft hangers should sustain damage typical for their structural types. Bulk fuel storage facilities, which are typically steel tanks, may rupture or suffer piping breaks due to loss of bearing strength and differential settlement. Portions of runways, taxiways and aprons, however, are likely to be available. These paved surfaces exert very little pressure on the earth in an unloaded state and, therefore, can be estimated to survive major ground shaking. Emergency planners should keep in mind, however, that serious liquefaction and differential settlement of the subgrade beneath the pavement can cause misalignment of these surfaces which could be great enough to prevent their use. Airport navigational lighting systems are comparatively simple and resilient and may survive the Ms =7.6 or Ms = 8.6 scenarios. They are, of course, susceptible to electrical distribution system failure, since back-up power may not be provided. Many navigational aids are sensitive electronic instruments which rely upon careful calibration and adjustment. It is unlikely they would be available for use following an occurrence of either postulated earthquake.

3.6 Public Utilities

This section of the report discusses the general aspects of the four main urban utility systems surveyed for this project. These are electric, water, natural gas and sewage utility systems. The following table gives a brief summary of the estimated availability of these systems, following an occurrence of the Ms=7.6 earthquake scenario. All systems are estimated to be unavailable following the Ms=8.6 earthquake scenario.

Estimated Availability of Utility Systems
All Cities

Ms=7.6 Earthquake Scenario

City	Electric	Water	Gas	Sewer
Memphis	U	U	U	M*
Little Rock	U*	A	M*	A
Evansville	U	U	U	U
Paducah	U	U	U	U
Carbondale	U	U	U	U
Poplar Bluff	U	U	U	U

U - System likely to be unavailable.
M - System <u>may</u> be available.
A - System likely to be available.
* - Limited and/or modified use possible.

3.6.1 Electric Utilities

Substation equipment is usually positioned and held in place by gravity, not securely fastened or bolted down. Massive transformers, voltage regulators, structures, racks and other substation equipment can often withstand several times their own weight in a vertical direction. However, this same equipment can sometimes withstand very little force in other directions. Horizontal and rotational, as well as vertical, forces affect even the strongest structures during earthquakes which can result in severe substation damage. Resultant damage due to a severe earthquake may include: slab (pedestal) mounted transformers and voltage regulators inadequately secured can be estimated to "slide" or "bounce" off pedestals causing major damage to bushings, lightning arrestors, cooling coils, internal parts, control cables and interconnecting buses. Internal coils and parts generally have poor lateral support. Unrestrained substation battery racks may collapse resulting in battery damage or rack damage or both and interconnections may fail due to insufficient slack. Poor weld penetration may result in failure of equipment support, causing equipment damage. Also, welds designed to resist wind loading alone will probably be inadequate. Motion of control (relay) cabinets may result in loss of functions and unsecured switchgear may cause damage to connections to the equipment. Platform mounted equipment may tip over snapping conductors, breaking insulators and spilling oil which could contain PCB material and could cause fires. Porcelain lightning arrestors, large power circuit breakers and disconnect switch assemblies are highly susceptible to failure. For 161 kV and larger substations, these are probably the most susceptible of all equipment. Pressure relays will be activated by sudden oil surges causing the equipment to trip off the line. Inadvertent operation of relays will also cause line tripping. Circuit breakers can trip or close incorrectly. Equipment will disconnect from structures, or the structure itself will deform to the point where the sectionalizing device can no longer function correctly. Conductors will become entangled or wrapped on adjacent conductors on power line spans.

No attempt is made to estimate the damage that could occur on distribution feeders leaving the substation. However, structural damage will occur to pole and pole line hardware. Faulted sections of the distribution system should be tripped out of service by sectionalizing devices.

Outage time for each electric system will depend on the extent of damage, work crews available, construction equipment, road access to substations, ability of transmission interconnection to restore service to substations, access to a mobile spare or spare transformer, transportation of spare, or whether a new transformer needs to be purchased. Loss of transformers can cause major longterm disruption of power since they cannot be bypassed as can some other damaged substation equipment. It must be remembered that, except for fringe damage areas, generally no assistance (manpower or equipment) can be estimated from neighboring utilities, as they will be experiencing equivalent difficulties in the earthquake scenarios of this study. Outage time could range from a few hours to a few months.

3.6.2 Water Systems

Water Source

In most cases, raw water is pumped from the source to the water treatment facilities. If an earthquake resulted in the loss of electrical power, most cities would have no means of obtaining raw water until power was restored, unless a source of auxiliary power is available. For cities which obtain their raw water from rivers (Paducah and Evansville - Ohio River, Poplar Bluff - Black River), the only adverse effect associated with the water source is the loss of electricity and subsequent inability to pump water. Cities which take raw water from surface water reservoirs (Carbondale and Little Rock) may lose their entire water supply due to dam or levee failure. Also, damage to raw water intake structures and raw water pipelines connecting sources to treatment plants is a further possibility for system disruption. Memphis uses groundwater as its source of raw water. In the event of a major earth movement, the well pump motors, casing, foundations and piping could be sheared apart resulting in the loss of wells.

Water Treatment Facilities

Once the raw water is pumped to the treatment facility, it generally flows by gravity through the unit processes. Treated water is normally stored in underground reservoirs or clearwells and is pumped into the distribution system as needed. Without electrical power, water treatment plants essentially would be inoperable. Chemical feed systems and mixers could not be operated and treated water could not be pumped into the system unless a source of auxiliary power is available. With the occurrence of a major earthquake, the possibility also exists that the treatment facilities themselves and/or the piping between units would be damaged to such an extent that they could not function. Sedimentation basins, aerator buildings, filter buildings, and pumping stations are all susceptible to earthquake damage.

Storage

With the loss of electrical power, a city's sole source of water would be that which has been stored and flows into the distribution system by gravity from elevated storage tanks and standpipes. Storage tanks at or below ground level which require the use of pumps to transfer water into the distribution system would be inoperable unless auxiliary power is available. In many cases, only one tank has an auxiliary power source so that in the event of a major earthquake, potable water would be very scarce. Damage to the water storage tank itself, particulary the elevated type, may render it inoperable. The elevated structure may collapse totally or the riser pipe may be sheared. The loss of an elevated tank in this manner would result in water damage in the immediate vicinity of the tank as it emptied.

Distribution

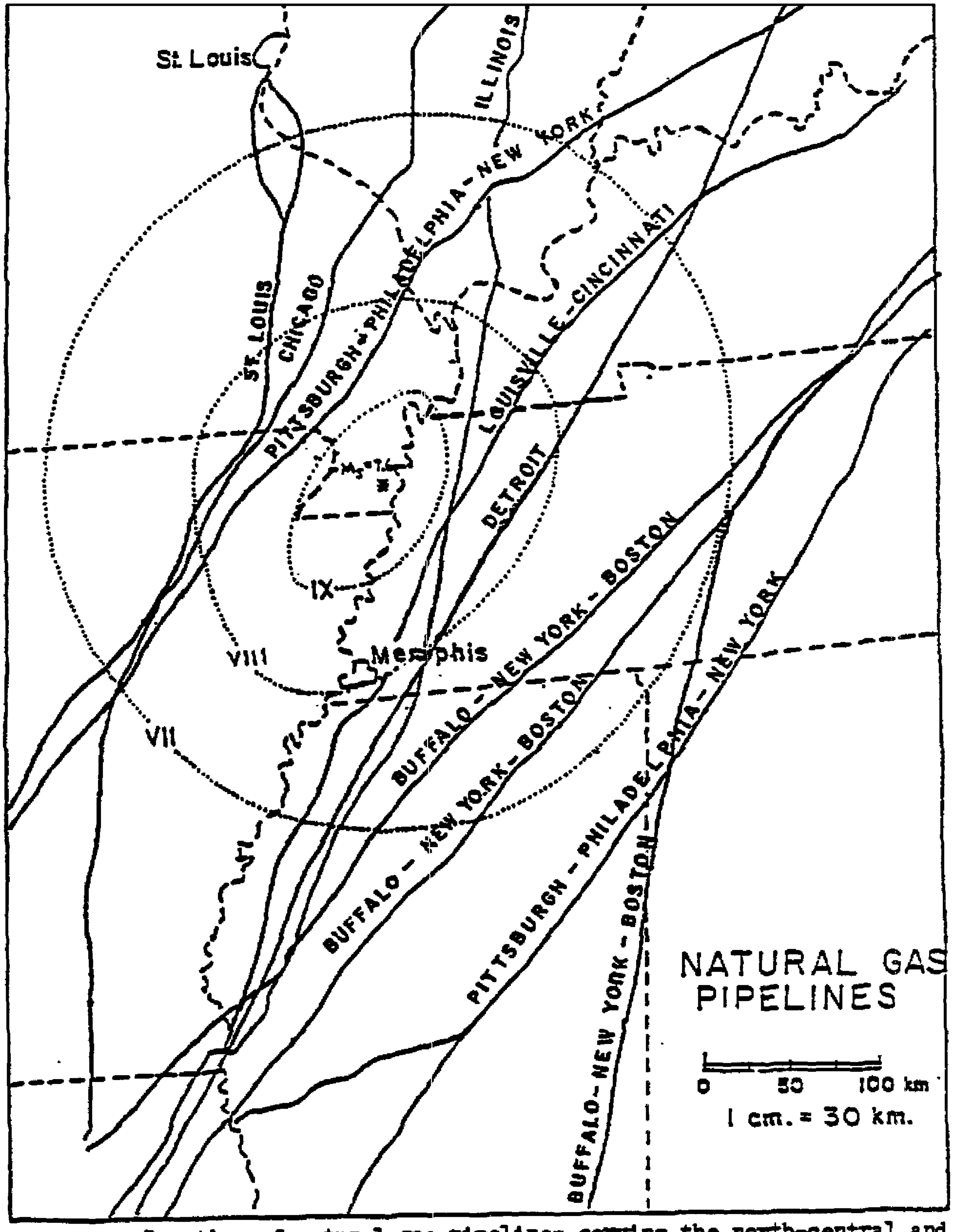
Even if potable water is available from storage, broken water mains could prevent delivery to the customers. Water distribution systems generally are composed of cast or ductile iron pipe, concrete pipe, or plastic pipe. Plastic pipe is very flexible and would best withstand the movement associated with the earthquake. Both concrete and iron pipe are rigid and, although these materials can withstand a certain amount of movement, would be more susceptible to cracking and rupture. Pipe joints in water systems are primarily the push-on type. Therefore, even if the pipe itself withstands the quake, the differential earth movement may cause separation at the joints. In general, it is anticipated that water distribution systems would experience major damage and, for the most part, become inoperable during a major earthquake. Repair and replacement of the damaged pipe would be a time consuming and expensive process.

Many cities utilize booster pumping stations to increase flow and pressure to outlying portions of their service areas or to fill elevated storage tanks. With the loss of electrical power these stations would be out of service for some period of time. A major quake could also result in complete destruction of the stations or damage to the piping and pumping equipment which would render them inoperable.

3.6.3 Natural Gas Systems

Natural gas transmission systems (intra- and interstate pipeline systems) are constructed almost exclusively with welded steel piping. These systems are generally made up of large diameter (12" through 42") underground piping operating at up to 1,000 psig. Several of these large diameter pipelines pass through or near the cities being considered in this study. These systems transport natural gas from the Gulf of Mexico area to major cities in the North and Northeast. Figure 3-1 shows these lines within the study area.

Failure of a section of interstate pipeline is likely during a major quake. However, these systems generally consist of several parallel piping runs that can easily be isolated. Assuming the failure of a few individual piping sections, the pipeline operators could readily valve off these sections of piping and maintain service to the various distribution systems that they serve. The most severely affected areas from actions of this nature would not be the cities in the immediate quake area, but would be the large load centers in the North and Northeast (New York, Chicago, Detroit, etc.) that depend on these pipelines for gas service. In the event of the loss of sections of piping in the middle of these pipeline systems, service at the outer end of the system would have to be curtailed drastically. Of course, the possibility exists that all large lines serving a region may be broken.



Location of natural gas pipelines serving the north-central and northeastern United States that pass near the New Madrid fault. Also shown are the VII, VIII and IX generalized isoseismals (dotted lines) for an $M_S = 7.6$ earthquake assumed to occur in the southeast part of the Missouri bootheel. There is enough strain presently stored up along the New Madrid fault to cause such an earthquake, if it were to happen right now. For poor soil conditions add 1 to 2 units to the intensity value shown in the figure. For outcropping hard rock, subtract 1 or 2 units from the intensity value shown in the figure.

FIGURE 3-1

Reference 26

The natural gas distribution systems serving the six (6) cities in question receive natural gas from interstate pipelines, reduce the pressure of the gas and distribute this gas to residential, commercial and industrial customers in and around the six cities.

The natural gas distribution systems in these cities include welded steel, cast iron and polyethylene piping. Polyethylene piping is very flexible and probably would withstand well the movement associated with either of the scenario earthquakes. Steel piping has some flexibility but would probably break in a few isolated cases. Cast-iron piping is very brittle and would undoubtedly crack and rupture in many places. Much of the cast iron in these natural gas systems is scheduled for replacement during the years ahead. However, there will be some cast-iron gas piping remaining in the ground for at least another ten to fifteen years.

In general, natural gas distribution systems would have to suspend operations after a major quake. To repressurize the systems will involve a time consuming process: (1) shutting off individual service lines, (2) pressurizing a small section of main line piping, (3) repairing any leaks found in that section, (4) reconnecting service piping to occupied buildings, (5) relighting pilot lights of appliances in individual buildings; and then repeating the entire process over and over as service is gradually restored throughout the systems. In many areas of cast-iron piping, due to its brittle nature and weak points, the entire main would have to be replaced during this process.

In addition to piping, other areas of concern in natural gas systems would be compressor stations on the interstate pipeline systems and pressure regulator stations in the distribution systems. Taking compressor stations out of service would diminish service to the pipeline's upstream customers. Pressure regulator stations are a critical part of each gas distribution system. While a few of these stations might rupture and release gas to the atmosphere, there should be no major problems arising from these stations.

Natural gas is lighter than air and while some line ruptures and leakage would occur following a quake, most of the leaking gas would harmlessly diffuse into the atmosphere.

The time estimates made for system inspection, repair and restoration presume the existence of necessary crews, equipment and replacement parts.

3.6.4 Wastewater Systems

The wastewater system for a city consists of a collection system and a treatment system. The collection system generally is made up of a network of pipe and lift stations. The wastewater treatment plant (WWTP) usually includes a number of processes which remove solids, Biochemical Oxygen Demand (BOD), and other pollutants from the wastewater.

Generally, wastewater is transported through the collection system to an influent pumping station at the WWTP. The wastewater is pumped into the first treatment unit and from there flows through the system by gravity. With the occurrence of a major earthquake it is assumed that electrical power will be lost for a period of time and that the natural gas distribution system will be shut down. Under these circumstances, the influent pumping station will be inoperable unless auxiliary power is available. Generally, for most of the cities, a method of bypassing the wastewater treatment plant is available. Although discharging untreated wastewater is not desirable, the primary purpose of the wastewater system during an earthquake will be to transport the wastewater out of the populated area to minimize the health hazards. In an emergency situation, actual treatment of the wastewater may be considered by authorities as secondary in importance to the health hazard. Significant earth movement also could result in extensive damage to the treatment facilities and/or the piping between units. In this case treatment would be impossible.

Carbondale, Evansville, Little Rock, Memphis and Paducah all have secondary wastewater treatment facilities. The activated sludg process generally consists of grit removal, clarification, aeration, chlorination, and sludge handling. The treatment units and their corresponding equipment, blowers, pumps, controls, etc., are all susceptible to earthquake damage. Poplar Bluff has three lagoons which require little operating equipment and could continue treatmen provided that the wastewater could be transported to them. A major quake could damage or destroy the lagoon levees in which case the treatment system would be lost.

Without electrical power, the wastewater lift stations, which are dispersed throughout each city's collection system, would not operate. Often these stations have bypass facilities which would serve the purpose of removing wastewater from the populated areas. Structural damage to a station building or damage to the pumping equipment also would render the lift station inoperable.

The sewer network operates by gravity flow of the wastewater in the pipes. The most common pipe materials in the six cities surveyed for this study are concrete and clay. Plastic pipe also is used, although not as extensively. Iron pipe is used in special cases such as stream crossings. Force mains are concrete, iron, or plastic. Plastic pipe is flexible and would best withstand the movement associated with an earthquake. Concrete, clay, and iron pipe are rigid and, although these materials can withstand a certain amount of movement, are more susceptible to cracking and rupture. Pipe joints in sewer systems are primarily the push on type. Therefore, even if the pipe itself withstands the earthquake, the differential earth movement may result in separation at the joints. It is anticipated that even if the WWTP is inoperable and some sewers collapse or are blocked, the remaining sewers and manholes can be used for wastewater storage for some period of time. Under the circumstances of disaster caused by a major earthquake, the storm sewer system could be used to transport wastewater in those cities which have separate storm and sanitary systems.

3.7 Dams and Levees

With the exception of Paducah (and possibly Poplar Bluff), none of the cities faces life-threatening risk due to the failure of dams and levees. Except for these two cities, none have dams of significance near enough to have an important effect. Paducah is only a relatively short distance downstream from two large reservoirs, restrained by earthern dams. Poplar Bluff may risk flooding from a relatively distant reservoir. These situations are discussed in the respective cities' sections.

All cities except Poplar Bluff and Carbondale are subject to flooding due to damage to their levees. The flooding will displace persons, but is not likely to cause significant casualties. Table 3 in Section 3.9.2 presents a summary of persons displaced and areas flooded for the four cities subject to this risk. Maps depicting inundated areas of the four cities subject to flooding are included in the individual city sections.

3.8 Residential, Commercial and Industrial Buildings

The number of residential structures which would suffer moderate structural damage or greater was used as the basis for estimating the number of displaced persons in each city. Some structures in that category would still be habitable, after a thorough inspection, even though they would require repairs, while others would not be habitable until the repairs were completed. Those with severe structural damage would most likely have to undergo extensive repairs or be rebuilt. The number of residential structures estimated to collapse provided the basis for the estimation of residential casualties.

The numbers of single family and multi-family dwelling likely to suffer collapse are summarized in Table 3-6.

Also used in the estimation of casualties were the numbers of commercial, industrial and public non-educational buildings which would be estimated to collapse. Those numbers are shown in Table 3-7 for wood frame structures and all other types of construction.

3.9 Casualties

Included in the following summary of the estimated casualties which would be produced by the two earthquake scenarios are the

TABLE 3-6

SUMMARY OF ESTIMATED COLLAPSES OF RESIDENTIAL STRUCTURES PRODUCING CASUALTIES

City	Total Number Of Structures		Estimated Number of Collapsed Structures			
			Ms=7.6		Ms=8.6	
	Single Family[1]	Multi-Family[2]	Single Family	Multi-Family	Single Family	Multi-Family
Carbondale	7,747	700	1	22	18	40
Evansville	37,336	2,062	2	42	42	80
Little Rock[3]	59,002	14,974	0	1	3	5
Memphis	140,943	12,805	311	128	1,818	316
Paducah	9,792	1,021	5	120	44	237
Poplar Bluff	4,429	1,195	4	2	23	4

[1] Assumed to be almost all wood frame, as indicated in survey data.

[2] Consisting of wood frame as well as other types of construction.

[3] The number of units instead of the number of structures was provided in the survey data.

TABLE 3-7

SUMMARY OF ESTIMATED COLLAPSES OF COMMERCIAL, INDUSTRIAL AND PUBLIC NON-EDUCATION STRUCTURES PRODUCING CASUALTIES

City	Total Number Of Structures		Estimated Number of Collapsed Structures			
			Ms=7.6		Ms=8.6	
	Wood Frame	Other	Wood Frame	Other	Wood Frame	Other
Carbondale	452	271	0	43	2	77
Evansville	403	3,349	0	423	0	930
Little Rock	482	1,474	0	49	0	159
Memphis	1,589	7,969	2	2,507	20	3,623
Paducah	174	1,435	0	365	2	583
Poplar Bluff	306	220	0	4	1	16

deaths and injuries and the displacement of persons which are estimated to result from structural failure and from flooding.

3.9.1 Deaths and Injuries

The deaths and injuries related to structural failure which are estimated in the six cities of the study area are summarized in Table 3-8. Not included in the table are the casualties which would result from flooding. The casualties estimated for schools and universities are shown seperately from those calculated for the population in general. Further breakdowns by residential, non-residential and hospital casualties are provided below for the individual cities.

In relation to each city's population, the estimated deaths would be as follows:

		Estimated Deaths per 100,000 Population*			
		Ms=7.6		Ms=8.6	
City	Population	Night	Day	Night	Day
Carbondale	31,670	92	234	218	505
Evansville	135,950	20	167	43	362
Little Rock	179,780	2	36	5	120
Memphis	643,540	33	392	68	588
Paducah	42,020	112	276	240	478
Poplar Bluff	17,140	6	99	23	303
TOTAL	1,050,100	30	288	64	467

*Based upon U.S. Bureau of Census Figure

Not shown above are the estimated injury rates, which would be approximately four times the death rates in each case.

The death and injury rates are relatively low in Little Rock because of the low earthquake intensities estimated for that city. The rates are also somewhat lower in Poplar Bluff than in the other four cities, primarily because of the small proportion of non-wood frame structures in that city, in comparison with the other cities. However, most schools in Poplar Bluff are not wood frame structures,

TABLE 3-8

SUMMARY OF ESTIMATED CASUALTIES RELATED TO STRUCTURAL FAILURE IN THE SIX CITIES

City and Population Segment		Ms=7.6				Ms=8.6			
		Deaths		Injuries		Deaths		Injuries	
		Night	Day	Night	Day	Night	Day	Night	Day
Carbondale	Gen. Pop.	9	24	34	94	16	43	66	17[illegible]
	Schools		22		87		40		[illegible]6
	Univers.	20	28	79	110	53	77	211	[illegible]0
	TOTAL	29	74	113	291	69	160	277	[illegible]64
Evansville	Gen. Pop.	23	155	108	621	58	337	133	1 [illegible]4
	Schools		72		290		155		[illegible]2
	TOTAL	23	227	108	911	58	492	133	1,96[illegible]
Little Rock	Gen. Pop.	3	51	10	204	8	167	34	[illegible]6
	Schools		10		40		36		14[illegible]
	Univers.		3	1	13	1	13	5	5[illegible]
	TOTAL	3	64	11	257	9	216	39	36[illegible]
Memphis	Gen. Pop.	203	1,796	813	7,179	421	2,627	1,681	[illegible]
	Schools		651		2,602		1,016		4[illegible]
	Univers.	8	76	31	305	14	143	57	[illegible]
	TOTAL	211	2,523	844	10,086	435	3,786	1,738	15,1[illegible]
Paducah	Gen. Pop.	47	92	185	369	100	156	397	[illegible]
	Schools		21		86		38		1[illegible]
	Univers.		3	1	11	1	7	3	[illegible]
	TOTAL	47	116	186	466	101	201	400	8[illegible]
Poplar Bluff	Gen. Pop.	1	2	4	9	4	10	17	[illegible]
	Schools		15		58		42		1[illegible]
	TOTAL	1	17	4	67	4	52	17	2[illegible]
TOTAL	Gen Pop.	290	2,120	1,154	8,476	607	3,340	2,428	1[illegible]3
	Schools		791		3,163		1,327		5,3[illegible]
	Univers.	28	110	112	439	69	240	276	9[illegible]
	TOTAL	318	3,021	1,266	12,078	676	4,907	2,704	1[illegible]5

Note: The numbers are shown as they resulted from the calculations. The result w[illegible] not rounded so as not to distort the results in cities with few casualties. The presentation of unrounded numbers is not intended to imply a precise estimate.

with the consequence that 80 to 90 percent of the casualties which would be produced by a daytime earthquake would occur among school children. Carbondale would also experience a substantial portion of its casualties among school children and university students.

The higher casualty rates are a consequence of higher estimated earthquake intensities and the location of the population in more vulnerable types of construction. As a general rule, the nighttime casualties would be relatively low, since the larger residential areas in the six cities are located mostly in the areas of lower intensity and consist primarily of wood frame structures. On the other hand, estimated daytime casualties are several times greater than the nighttime casualties because much of the population moves from relatively safe residential structures into buildings which are much more vulnerable to earthquake damage (most schools, commercial, industrial and public structures are of masonry bearing wall or shear wall construction) and which are often located in areas with greater estimated earthquake intensities. In Paducah, however, the nighttime casualties would be proportionately high, primarily because of the large number of non-wood frame multi-family residences which are found in that city.

The casualties per 100,000 population, especially for a daytime occurrence of the postulated earthquakes, are somewhat higher than those experienced in the recent past in the United States and those estimated for other areas of the United States in previous studies. The higher casualty rates estimated in this study are a consequence primarily of the more vulnerable types of construction in the six cities (and especially in Memphis). In general, the buildings in the six cities have not been built to the seismic building codes which typically have been used in areas for which casualty estimates have been prepared in previous studies (such as San Francisco and Los Angeles) or where most U.S. earthquakes have occurred. The difference is more noticeable for daytime than for nighttime casualties, since in the latter case wood frame dwellings with similar seismic characteristics house most of the people in both the current and previous study areas as well as in the areas where earthquakes have been experienced.

A substantial portion of the daytime casualties are estimated to occur among primary and secondary school children, as follows:

City	Estimated School Deaths Ms=7.6	Estimated School Deaths Ms=8.6	%of Total Daytime Deaths Ms=7.6	%of Total Daytime Deaths Ms=8.6
Carbondale	22	40	30%	25%
Evansville	72	155	32	32
Little Rock	10	36	16	17
Memphis	651	1,016	26	27
Paducah	21	38	18	19
Poplar Bluff	15	42	88	81

Injuries to school children would constitute a similar proportion of total injuries. The school casualties would be caused by the large number of estimated collapses of school buildings, since most schools in the six cities are of unreinforced masonry bearing wall construction.

Casualties from flooding would be significant only in Evansville, where damage to levees could result in the inundation of rather densely populated areas. Four cities could experience casualties from flooding, estimated as follows for both an Ms=7.6 and an Ms=8.6 earthquake:

City	Estimated Casualties from Flooding	
	Deaths	Injuries
Evansville	3	3
Little Rock	1	1
Memphis	1	1
Paducah	1	1

The flooding casualties were estimated on the basis of the number of people which would be displaced in the inundated areas, as explained previously in Section 2.5.2.

3.9.2 Displaced Persons

Displacement of persons would be caused by damages to residential structures and by the flooding of residential areas in the event of the failure of dams or levees.

The number of persons who would be displaced because of damage to their residences is estimated as follows:

Estimated Number of Persons Displaced Because of Structural Damage

y	Ms=7.6			Ms=8.6		
	Type of Residence			Type of Residence		
	Single Family	Multi-Family	Total	Single Family	Multi-Family	Total
bondale	3,000	2,730	5,730	6,575	4,500	11,075
nsville	7,580	3,510	11,090	29,350	9,500	38,850
tle Rock	1,110	1,330	2,440	9,075	12,625	21,700
phis	159,100	72,600	231,700	239,500	114,250	353,750
lucah	6,320	7,000	13,320	12,475	10,125	22,600
lar Bluff	2,440	3,300	5,740	4,075	6,500	10,575
AL	179,550	90,470	270,020	301,050	157,500	458,550

For an earthquake of magnitude 7.6, the displaced persons would amount to only about one percent of the total population in Little Rock, eight percent in Evansville and 18 percent in Carbondale. In Memphis, Paducah and Poplar Bluff, however, approximately one third of the population would be displaced and require temporary shelter.

The percentages of displaced persons would increase substantially for a Ms=8.6 event.

Persons were assumed to be displaced and to require temporary shelter if their residences suffered at least moderate structural damage. Some of those persons would be able to return to their residences fairly promptly following basic safety measures; others would require long-term shelter until their residences could be repaired or replaced.

Temporary shelter would also be required by some residents if flooding as a result of damages to dams or levees should occur. The number of persons subject to displacement from flooding is estimated as follows, with no distinction being made between the two postulated earthquakes:

City	Number of Persons Displaced Because of Flooding
Evansville	24,500
Little Rock	3,500
Memphis	10,100
Paducah	5,000

These estimates are very conservative, since they assume that water levels would be abnormally high at the time of the earthquake and that levees (and, in the case of Paducah, dams) would be damaged in such a way as to allow the entire protected 100-year flood plain to be inundated. Most of the time, little or no water is retained by levees in the study areas. Maps depicting the flooded areas are included in the individual city sections.

Other studies have indicated that a failure of the Wappapello Reservoir, northeast of Poplar Bluff may contribute to flooding in the vicinity of that city.

3.10 Large Fires/Conflagrations

Due to numerous undefined and uncertain aspects of this topic, it was not possible to make actual estimates of locations and numbers of persons affected by large fires or conflagrations. Certainly many factors favoring large fires will be present following an occurrence of either earthquake scenario. Among these are lack of water and needed equipment to fight fires, sources of ignition such as ruptured gas distribution pipes or chemical spills, possible high winds, as well as many other miscellaneous contributors. Conversely, construction types and densities would argue against widespread, huge fires. The approach taken for this project is that very large fires, engulfing major portions of an urban area are unlikely. Smaller "group" fires, involving several buildings are probable; some authorities would term these fires "conflagrations". Of course, any storage point of flammable materials is a potential site for a serious fire. These would often be confined to the immediate vicinity of the fuel source.