Emergency Preparedness

The state of Colorado covers a vast area. If an accident involving high-level nuclear waste were to occur in a remote region, state agency officials in Denver could find it difficult and time-consuming to reach the scene. Even in good weather, it could take up to ten hours to reach an accident, and if the weather were bad and mountain roads had to be traversed, it could take up to twenty hours (Foster and Jordan, 1984).

In addition, in order for accident response to be effective, extremely expensive resources and expert human skills would probably be required; yet these resources and skills are often beyond the budgets and capabilities of local jurisdictions. Nonetheless Colorado statute assigns responsibility for emergency response to local government. Thus, providing accident response "is likely to constitute a significant problem for any local government" (DODES, 1984, p.1).

These difficulties notwithstanding, having a good response plan and doing a lot of work, including cooperating with other local governments, before an accident occurs could make it easier for a local jurisdiction to effectively allocate its resources. Although emergency response programs can be expensive, the cost is minor compared to the actual costs of accident management and clean-up. The cost of a state "Transportation Incident Branch" to handle emergency response to radiological materials transportation incidents, employing 100 people (modeled after an existing agency in Southern California) has been estimated at $5.6 million for one year (Gunderloy et al., 1981).

With a few exceptions, on both the state and local levels, Colorado does not have the resources necessary for adequate planning or response. For example, the Colorado State Health Department is not equipped to provide on-site technical assistance in the event of a major incident involving hazardous materials. A survey taken in 1984 found that only 25 of 170 local emergency response agencies had the minimum training and equipment necessary to effectively deal with such an incident (Walker, 1985). Denver's Mayor Federico Pena has stated that with the large number of nuclear waste shipments planned to come through the city, accidents will happen, and that Colorado's largest city, with a rather sophisticated hazardous materials response team, is "certainly not prepared to deal with radioactive spills of the magnitude and variety [we] are likely to see" (KCTS-TV, 1986). He also observed that Colorado's small towns and rural areas would find themselves "totally at the mercy" of a federal response team, who could take hours (or days) to arrive at the site and deal with a spill (KCTS-TV, 1986).

State Agencies

Division of Disaster Emergency Services (DODES). The Colorado Division of Disaster Emergency Services (DODES) deals with disaster mitigation, preparedness, response, and recovery and coordinates activities of other state agencies in these four areas. The specific responsibilities each agency assumes during an emergency are spelled out in the Colorado Natural Disaster Emergency Operations Plan.

The DODES is also responsible for overseeing local preparedness and emergency planning activities, reviewing local preparedness plans, and monitoring current preparedness and recovery research.

In the course of working on state preparedness, the DODES has studied county-level activities. Twenty of Colorado's 63 counties contain 90% of the state's population. For the 43 sparsely populated counties that contain the remaining 10%, the agency found that many "have effective life saving plans and organizations under a sheriff, police, or fire authority that will effectively save lives when extreme [natural hazard] events occur" (DODES, 1983, pp.8-9). Most, however, will need rapid, effective support from state agencies to assist with damage assessment and recovery operations. Therefore, to ensure quick response, "a strongly improved emergency communications capability is developing so that redundant systems can extend across the State" (DODES, 1983, p.31). Three-quarters--all the mountainous section--of the I-70 study area lies within some of these sparsely populated counties.

Colorado State Patrol. The state patrol's role during emergencies is primarily to deal with traffic. Local personnel in the field have the responsibility for determining if an emergency exists and then taking immediate, appropriate action.

Unique Attributes of I-70

In Colorado one of the unique features of Interstate 70 is the Eisenhower Memorial Tunnel. The tunnel is actually two tunnels: one for westbound and one for eastbound traffic. The tunnel is 1.7 miles long and handles around 5.5 million vehicles every year. This "volume of traffic alone raises questions about how safe the tunnels are, and if they need to be made safer" (Brimberg, 1986). Since 1977 there have been 90 accidents in the tunnel; twenty-four were injury accidents and two involved fatalities (Brimberg, 1986). (Although the first bore of the tunnel was opened in 1973, accident records were not kept until 1977.)

Tunnel officials believe the Eisenhower Tunnel is the safest part of the Colorado interstate system, but they are still taking steps to make it safer. The tunnel has a television monitoring system which enables emergency crews to spot and reach accidents in three to five minutes, depending on traffic. The tunnel employs other safety measures as well: a twenty-four hour emergency crew of four (normally), a high-speed ventilation system, three fire trucks located at the east end of the tunnel, and back-up help available from the

Silverthorne Fire District. Officials are also now preparing a plan for mass evacuation of the tunnel. Such a plan has not been developed previously because shift work crews were not always large enough to carry out an evacuation.

Tunnel safety is also increased by the regulation of vehicles that can pass through the tunnel. Vehicles carrying 1,000 or more pounds of combustible liquids are not allowed to use the tunnel, and smaller loads of flammable liquids can be prohibited as well. Many other types of dangerous cargoes are also banned. As stated earlier, trucks hauling banned substances must take an alternate route--Loveland Pass--almost ten miles of winding road that passes the Keystone ski resort complex and the community of Dillon, rejoining I-70 at Silverthorne. When Loveland Pass (U.S. 6) is closed by bad weather, the banned trucks must wait near the Eisenhower Tunnel in the truck parking areas. Once the regular tunnel traffic has cleared, banned trucks move in a convoy, on the hour, through the tunnel.

Personnel are located at each end of the tunnel to monitor the vehicles passing through and to enforce the safety regulations. If caught, a hauler who has ignored the regulations can be fined up to $1000 and sentenced to one year in jail.

There is approximately 85% compliance with the hazardous materials regulations. Some of the trucks that do slip through do so because they are not carrying the required warning signs. To aid the enforcement personnel, officials are adding cameras at the tunnel approaches to monitor trucks carrying hazardous materials.

Natural Hazards

Natural hazards, with the exception of the effects of weather on the repository's long-term delivery schedule, have not been given much consideration with respect to spent nuclear fuel transport. This is troubling because natural hazards can increase the likelihood of a technological disaster. Numerous natural hazards are found along the I-70 route and deserve serious attention, particularly by those who would have to respond to a natural disaster involving a truck transporting nuclear materials. For example, an avalanche could render a mountain road impassable, cause vehicles to be stranded, or bury a truck under tons of snow.

Overview

Colorado is vulnerable to a variety of hazards: avalanches, dam failure flooding, flash flooding, riverine flooding, landslides, earthquakes, severe winter storms, tornadoes, and other severe weather. Of these hazards, the DODES has established dam failure flooding, flash flooding, riverine flooding, earthquakes, and tornadoes as Colorado's very high-risk hazards; all can have enormous impacts.

DODES has identified the areas under the greatest threat from very high-risk hazards and the populations which are threatened (DODES, 1983). Risks due to natural hazards are often interrelated and the occurrence of one can enhance the likelihood or compound the effects of another. For example, a flash flood could trigger the failure of a dam, thus compounding the overall flooding.

Not only is Colorado's resident population at risk from the state's natural hazards, visitors are also at risk. Tourism is the mainstay of many mountain areas of the state identified as being at risk from natural hazards, and tourists compound the problem because they are unfamiliar with these hazards or with the steps to take when a disaster (a flash flood comes immediately to mind) is imminent.

Avalanches

In 1974 Colorado enacted House Bill 1041, the "Land Use Act." It provided for identification, designation, and administration of areas and activities of state interest. One of the main purposes of the act was the regulation and management of natural hazard areas. These included flood plain hazards and geologic hazard areas--the latter areas being "where past, current, or foreseeable construction of land use would be affected by disturbances such as landslides, mudslides, earthquakes, or ground subsidence" (White and Petros,1977,1701).

The Colorado Land Use Commission provided model land use regulations and made funds available to counties so they could "identify and designate these matters of state interest" at county and municipal levels. The Colorado Geological Survey (CGS) provided technical assistance to identify geologic hazard areas and avalanche areas.

Avalanche hazards were mapped (Mears, 1979) for counties where the avalanche threat was the most urgent--i.e., locations where future development was likely in areas known to have such hazards. Two of the areas mapped--Silver Plume and Frisco--include avalanche paths which reach or cross Interstate 70. Avalanches also threaten the Vail area, yet none directly affect the route.

In the Silver Plume area, fifteen individual avalanche paths and three groups of small avalanches were identified. The small avalanches include a pair of paths that do not carry much snow and have no runout zone above I-70, but occasionally produce avalanches that reach the road. Of the avalanche paths, six south of I-70 and three north of the interstate can carry slides that reach or cross the road. Two of the south paths meet two from the north at I-70, and, in all instances, I-70 falls within hazard zones described as moderate. In the Frisco area four groups of avalanches and nineteen avalanche paths were identified and mapped. Nine of the paths south of the interstate can cross the road, with I-70 again falling within moderate hazard zones.

The potential for road-closing avalanches exists almost anywhere within the mountains of Colorado every winter. An interesting example occurred during the winter of 1985-86. On February 20, avalanches closed eastbound I-70 east of the Eisenhower Tunnel and U.S. 6 over Loveland Pass. Both avalanches were triggered by Colorado State Highway Department crews working to prevent the further dangerous build-up of heavy snows that threatened each route (Boulder Daily Camera, 1986a). The Interstate 70 slide, characterized as a "big one," was a controlled human-caused slide three miles east of the tunnel. It was fifty yards wide, twenty feet deep, and took road crews approximately three hours to clear. The snow threatening U.S. 6 had built up across from the Arapahoe Basin ski area. When triggered, the avalanche crossed U.S. 6 into the ski area, closing the road.

Dam Failure Flooding

The failure of a dam results in downstream flash flooding. Failure can be due to one of two causes: hydrologic or structural deficiencies. The latter (including such problems as seepage, cracking, general weakness) are most often caused by age, whereas hydrologic deficiency most often involves a spillway of inadequate capacity that causes overtopping when large amounts of water flow into the reservoir. There is also increasing information indicating that seismic risk must be taken into account when designing and building dams in Colorado, and that older dams that were not designed with this threat in mind pose a reasonably high risk to downstream areas.

The Office of the State Engineer has identified those Colorado dams (over ten feet high) which are hazardous to downstream land uses. Dams are listed by county (not by river) with the populations at risk identified "in very general terms" (DODES, 1983, p.27). This information is "not generally disseminated to local city and county officials [who are] responsible for public safety" (CWCB, 1985, p.138), and there is little public awareness of the damage which could occur due to a dam failure.

Hazardous dams are classified as being either a high, moderate, or low hazard, with a high hazard dam defined as one whose failure would cause one or more lives to be lost. Inundation zones for high hazard dams have been mapped, and communities potentially affected by the failure of a high hazard dam should obtain or develop worst case estimates of flooding and flood damage (CWCB, 1985). Without a current, tested response plan, the vulnerability of a community downstream from such a dam is very high.

The zones threatened by the failure of a moderate hazard dam can be estimated with sufficient accuracy to permit emergency planning. By definition, should a moderate hazard dam fail, no loss of life is expected, but the economic damage to agriculture, industry, and/or structures would be appreciable. In turn, the failure of a low hazard dam is not expected to result in loss of life, and economic loss would be minimal.

In the I-70 study area, there are two dams whose failure would cause the flooding of towns along the interstate. In Summit County, Dillon Reservoir dam threatens almost all of the downstream town of Silverthorne, and dam failure would result in severe inundation of the interstate through that town. Farther west, almost all of the town of Rifle would be threatened if the Rifle Gap Reservoir dam failed.

One of the largest known floods along the Colorado Front Range occurred on June 4, 1956 when the Georgetown Dam failed. The result was flooding along Clear Creek near Golden (also within the study area).

Flash Flooding

Flash flooding is one of the most pervasive natural hazards in Colorado, particularly in the mountains and Front Range flood plains. Obviously, these floods pose the greatest danger to "settlements located close to the major streams" (DODES, 1983, p.5); such settlements have been identified by DODES in the course of studying riverine flooding. In mountain regions and in south-western Colorado, flash floods occur annually--usually during spring and summer--triggered by heavy rainfall which may be combined with snowmelt. (Thus, thunderstorm floods are synonymous with flash floods.) To compound the hazard, flash flooding can often be accompanied by landslides in canyons and along river headwaters.

Hazardous flash flood areas are those having a concentrated population, steep gradients, and large drainages capable of focusing considerable quantities of water. Of course, they are also areas subject to very heavy rainfall; but unfortunately, in Colorado the amount of rainfall from a storm and the time over which it falls are the "most difficult [parameters] to predict and prepare for" (DODES, 1983, p.4).

The Colorado Geological Survey assessed the extent of Colorado's flash flood hazard following the disastrous 1976 Big Thompson Canyon flood, identifying the most hazardous canyons--i.e., the ones where "the intensity and degree of potentially hazardous geological conditions and the intensity of current development coupled with projections of near-term and future development pressures" pose a significant threat to the population (DODES, 1983, p.A-1). The bulk of the hazardous canyons are found along the Front Range. Table 4 lists those communities along I-70 which are at risk.

TABLE 4

HAZARDOUS CANYONS IN COLORADO

DRAINAGE	COUNTY	COMMUNITY AFFECTED
Clear Creek-Tucker Gulch	Jefferson	Golden
Clear Creek	Clear Creek	Idaho Springs, Empire, Georgetown, Silver Plume
Lower Blue River	Summit	Silverthorne
Tenmile Creek	Summit	Frisco, Copper Mountain
Gore Creek	Eagle	Vail
Brush Creek-Eagle River	Eagle	Eagle
Roaring Fork River	Garfield	Glenwood Springs & suburbs
Colorado River-Elk Creek-Canyon Creek	Garfield	New Castle
Rifle Creek	Garfield	Rifle

The DODES, as well, prepared lists of those areas of Colorado where people are especially vulnerable to flash flooding. They first adapted the CGS hazardous canyons list, comparing susceptable areas to existing settlement patterns. The result, a publication entitled "Major Flash Flood Canyons of Colorado," identifies Clear Creek Canyon as the only major flash flood canyon along the I-70 route (DODES, 1983, p.18). Therefore, the communities of Idaho Springs, Empire, Georgetown, and Silver Plume are considered at risk due to flash flooding because they flank the headwaters of Clear Creek.

The DODES then ranked their list by order of the number of people at risk, and produced "High Risk Flood Areas in Colorado" (DODES, 1983, p.19). The people living in the drainages of the identified canyons are subject to the greatest flash flood risk in Colorado because they are in immediate danger due to the hazard's short time of onset. By these calculations, the canyon containing Clear Creek has the second highest number of people at risk due to floods in Colorado.

Communities in high-risk flood areas will need to be well prepared--i.e., have well thought-out and rehearsed warning plans, evacuation plans, and response plans--to protect their populations. Their problems are made more difficult because weather radar may not be able to pinpoint severe thunderstorms over the mountains east of the Continental Divide--particularly if the cells are part of massive weather systems. In addition, on any given summer day, the tourist population can double some mountain area's population and exacerbate warning and response problems.

Riverine Flooding

Large scale riverine flooding can occur throughout Colorado in the spring, summer, or fall. A flood greater than a 100-year flood has occured in every large Colorado stream basin. Springtime--particularly May and June--is the most dangerous time for riverine flooding due to the combination of peak smowmelt runoff and possible sustained or concentrated rainfall.

Compared to flash floods, riverine floods lack steep gradients, have a slower onset, afford greater warning time, and involve fewer fatalities. However, they often cause greater property damage because areas subject to riverine flooding typically contain valuable farmland, roads, bridges, and other infrastructure. Riverine flooding can be compounded by the occurrence of simultaneous flash flooding in headwater areas having steep gradients.

Flood design standards have been adopted for highways so that the effects of a flood are factored into road design to allow passability during less than severe flooding. The 100-year flood standard is used for interstate and U.S. highways in urban areas; interstate highways outside urban areas are subject to a 50-year flood standard; and U.S. highways in rural areas are subject to a 25-year flood standard (or less).

Colorado Water Conservation Board (CWCB) data shows that three floods affected the I-70 study area during 1983. Rifle Creek flooded June 11-12 at Rifle; Clear Creek flooded June 25-28 around Silver Plume and Georgetown, and the Colorado River flooded June 22-28 within Garfield County. The CWCB has indexed Colorado's flood plain mapping (which varies considerably in quality and detail) by county, city/town, stream, study director, report title, engineer, and completion date (CWCB, 1983).

Landslides

House Bill 1041 defined three types of landslide hazards--landslides, rockfalls, and mudflows (including debris flows). All slopes recognized as possible areas for landslides are considered "unstable or potentially unstable slopes" when the event is imminent--they are in a state of highly unstable equilibrium. Identifying and managing landslide hazards is difficult, making them a very serious hazard, because landslides are not continuous processes, are widespread, and are hard to recognize. The most serious threat is "probably from [the] accelerated movement of marginally stable old slides" (CWCB, 1985, p.19).

In addition, as alluded to earlier, catastrophic landslides can affect flooding. They can dam streams and produce downstream flooding when the landslide-formed dam is eroded and breached, or they can discharge into a reservoir and displace water over the dam, causing downstream flooding.

At least half of Colorado's mountain and foothill areas are or have been susceptible to landsliding, and the Colorado Geological Survey believes "some of the best known existing landslide areas . . . have catastrophic potential" (CWCB, 1985, p.127). The agency has listed twelve such areas, two of which are within the I-70 study area (Table 5). Mitigation measures have been undertaken to contain the slides at Dowds Junction because of the potential economic and social impacts of sliding in that area (Boulder Daily Camera, 1986b). CWCB has also documented two mudslides in the study area, both affecting I-70 near Minturn--one during May 23-29, 1983, the other June 7, 1983.

Mudflows occur in the spring and summer months. They are triggered by heavy runoff from either intense rainfall or a sudden heavy snowmelt. Snowmelt mudflows are usually more extensive, and their threat can continue over several weeks.

Debris flow hazards have been documented for "areas where development and . . . hazards coexist and continue to represent severe problems" (CWCB, 1985, p.123). Three of these twelve areas are along the Interstate 70 corridor (Table 6).

Seismicity

The potential for damaging earthquakes in Colorado has been underestimated in the past, and it appears that "many critical structures (dams, hospitals, schools) have not been adequately designed for larger size earthquakes that now appear possible in Colorado." (DODES, 1983, p.6). The Colorado Geologic Survey has mapped the state's earthquakes, from 1870 to 1979, and Colorado's potentially active faults (Kirkham and Rogers, 1981). In addition, the U.S. Geological Survey has delineated earthquake intensity zones for Colorado. The mapping is based on the Modified Mercalli Intensity Scale, and

TABLE 5

KNOWN OR SUSPECTED POTENTIALLY CATASTROPHIC LANDSLIDE AREAS

Name of Slide and Location	Type of Slide(s)	Facilities at Risk
Whiskey Creek and adjacent slides in Eagle County at Dowds Junction and extending approximately one mile each way along the Eagle River.	Large earthflows and slope failure complexes. Currently affecting highways at several locations.	Interstate 70, US Highway 6 and 24 mainline of D and RGW Railroad, valley development and facilities including Minturn and West Vail.
Wolcott slide, located along Interstate 70 from vicinity of Wolcott southwesterly about 1.5 miles southwesterly to Bellyache Ridge in Eagle County.	Very large earthflow and slope failure complex. Currently shows continuing movement.	Interstate 70, US Highway 6, D and RGW Railroad, community of Wolcott.

TABLE 6

AREAS WITH DEBRIS FLOW HAZARDS AND DEVELOPMENT

Community	Location	Facilities at Risk
Idaho Springs, Georgetown and numerous smaller communities along Clear Creek in Clear Creek Co.	Clear Creek County.	Residential and commercial properties, streets and other public facilities.
Vail and adjacent developing parts of Eagle County.	Development corridors along Gore Creek and Eagle River, Eagle Co.	Residences, commercial properties, muncipal facilities: water, power, sewer, streets.
Glenwood Springs and vicinity.	City and adjacent lands in Garfield Co. along Colorado and Roaring Fork rivers.	Residences, commercial properties, streets and other public facilities.

areas are, therefore, classified based on the effects an earthquake would have on persons, structures, and the environment. In the study area Interstate 70 passes through zones VII and VIII. An earthquake of intensity VII has the following characteristics:

> Difficult to stand. Noticed by drivers of motor cars. . . . Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments. . . . Small slides and caving in along sand or gravel banks. (DODES, 1983, p.23)

The characteristics for an intensity VIII earthquake include:

> Steering of motor cars affected. Damage to masonry; partial collapse. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; . . . Branches broken from trees. . . . Cracks in wet ground and on steep slopes. (DODES, 1983, p.23)

<u>Severe Winter Storms</u>

The 1982 Christmas Eve blizzard in Denver illustrates an extreme in Colorado's winter weather. It is not uncommon for lesser blizzards to occur at any location across the state during the winter season. The Christmas Eve blizzard, however, was the fiercest twenty-four hour blizzard in Colorado's recorded weather history. The traditional mountain storm did not form; only ten inches of snow fell at Aspen and Vail. However, three-foot drifts formed on I-70 east of Denver, and the San Francisco Zephyr passenger train was stranded in Denver for 19 hours. The storm is particularly well remembered because the Denver city government chose to ignore its own snow emergency plan and did not mobilize equipment; officials did not believe the dire weather forecasts (<u>Denver Post</u>, 1983).

On December 24 at 8:00 a.m., Interstate 70 was closed east and west from Denver. A half hour later Interstate 25 was closed south from Denver, and at 12:30 p.m. Interstate 76 was shut down. The following day, I-25 reopened at 4:15 in the afternoon, and that evening at 7:00 p.m. I-70 was partially reopened. By midnight on Christmas day almost all major roads that had been closed were open. In all, I-70 was closed for about thirty-five hours.

As previously mentioned, the Eisenhower Tunnel is closed regularly in either or both directions each winter. Westbound traffic is stopped at Georgetown or Silver Plume while eastbound traffic is halted at Dillon. While the tunnel is closed, depending upon the severity of the weather, Loveland Pass may or may not be open and, if open, could have chain law restrictions in effect. Should a vehicle somehow get past the roadblocks halting traffic and reach the tunnel while it is closed, the vehicle would be turned around and sent back to the waiting point.

A typical closure of I-70, caused by a spring snowstorm, occurred in early April, 1985. Vail Pass was closed for more than three hours due to blizzard conditions; extreme whiteout and icing conditions resulted in jackknifed trucks and stuck vehicles along the pass. This same blizzard also closed Loveland Pass.

Weather can do more than close roads. In mid-March of 1985, I-70 from Vail to Eagle developed severe potholes almost literally overnight following a freeze-thaw cycle, creating a hazardous situation during heavy traffic when vehicles, trying to avoid the potholes, veered into other lanes (KCNC-TV, 1985).

Tornadoes

No tornado has been observed striking I-70 along the areas under study. However, tornadoes occur with considerable frequency along the eastern slope and plains of Colorado, making I-70 east of the mountains vulnerable. Colorado ranks seventh among the fifty states in tornado occurrence. Despite their frequent occurrence, Colorado's tornadoes are usually of relatively short duration and not as severe as those of the Midwest. According to the National

Weather Service (NWS) the greatest risk exists from May through July, and during this season "any Eastern Slope community must realistically expect and prepare for tornado impact" (DODES, 1983, p.25).

Weather

The National Oceanic and Atmospheric Administration (NOAA) weather radio warning coverage for Colorado is broadcast from six stations (DOC,1985). Broadcasts--taped messages repeated every 4-6 minutes and revised every 1-3 hours (more frequently if necessary)--contain the latest weather information fron NWS offices. Information is tailored to serve the needs of people in each station's receiving area. Special warning messages can be inserted, interrupting routine broadcasts. The Denver NWS office thus supplies the I-70 route with information from stations broadcasting out of Denver and Grand Junction.

For real-time weather reports, truckers are often their own best source of weather information; they provide each other (via CB radios) with information and descriptions of weather conditions along their routes, as well as information concerning road conditions, accidents, and road closures.

Computer Model

Rationale

Perhaps the main inference following from a study of the transportation of high-level nuclear wastes is that an accident may occur at any point along the transport route at any given time. Working from this assumption, it is apparent that state and local emergency preparedness activities would be aided by knowledge of those locations where an accident is highly likely to happen, the natural disasters whose occurrence could hamper evacuation efforts, the population distribution along the route, and the possible response/evacuation routes.

A computer model--containing data on accident frequency and location; special facilities; terrain; routes for response/evacuation; and present/projected road condition (including the effects of truck traffic)--could be developed to pinpoint those portions of the transport route that are most "sensitive." A sensitive location would exist where the potential for an accident is high, response and evacuation are difficult due to a limited choice of routes besides the main route, weather-related hazards (e.g., flash flooding, winter storms) would hamper emergency activities, and the existence of special facilities and/or seasonal populations complicate response.

Creating a computer model having the ability to identify these types of sensitive locations would be time consuming, requiring a significant amount of data collection and analysis. For example, one would have to decide whether a portion of the route with a large year-round population that could be easily evacuated, without natural hazards, with "average" accident rates, and with medium average daily traffic (ADT) was more or less sensitive than a section with a population that fluctuated due to seasonal recreation, with limited evacuation routes, "average" accident rates, and low ADT. A weighting system would have to be devised to reflect the exact natures of sensitive locations. Accident rates would have to be averaged over a sufficient time span to factor out highs and lows to present an accurate picture of accident data. This data might be further limited to include only large trucks, though a true picture of a location's sensitivity could be altered.

For the purpose of demonstration, a simple computer model was developed for the I-70 route to show how it is possible to identify sensitive locations using existing or easily generated data.

Data Base

The data base consists of three main collections of information--data on accidents, road conditions, and evacuation capabilities. The accident and road condition data, covering all types of vehicles, are limited to 1983, while the information on evacuation should hold over time, barring the construction of new roadways.

Colorado Department of Highways Data. During odd numbered years the Colorado Highway Department collects data on "Accidents and Rates on State Highways" and "Road Conditions." The accident data is collected for lengths of road which are identified by milepoints which correspond to the terminus of a given section. Sections are not of even length, and are identified as being urban or rural. Numbers of accidents--including property damage only (pdo) accidents, injury accidents, fatal accidents, and total accidents--are listed by milepoint. Accident rates--for injuries, fatalities, and total numbers of accidents--are computed based on the number of accidents per vehicle miles traveled during one year.

Road condition data, listed by mile, comprises various information including: ADT, environmental zone, equivalent daily load, a rutting factor, a roughness parameter, percent cracking, condition state, and projected maintenance action. The condition state, rated on a scale of 1-9, is calculated based on the amount of rutting and percent of surface cracking. These ratings can also be translated to good, fair, or poor road condition. The condition of a one-mile increment of road (identified by a milepost) is used to determine the maintenance it should receive: routine, minimum, or major. The road condition data lists the condition for the year the data was collected (Year 1), the maintenance action proposed for Year 1, and projects road conditions for Years 2-7 and maintenance actions for Years 2-6. The model used for the projections is based on current traffic; it does not take future increases or decreases into account. In the most recent survey, data are missing for mileposts 119 to 131 because this portion of I-70 was a projected route (presently under construction) through Glenwood Canyon.

Data Compiled for Computer Model. Information on population, terrain, and evacuation access are included in the evacuation data used in the model. The data are listed for each milepoint and milepost. Population was estimated for a one kilometer wide band along the route. Terrain classifications, interpolated from topographic maps, fell into one of nine categories ranging from rolling prairie to deep, narrow valleys/canyons with connecting valley(s), to pass summits. Maps were also used to determine evacuation access; lengths of road were classified according to one of five evacuation access codes:

1 = numerous evacuation routes available
2 = limited evacuation routes available
3 = limited evacuation route--1 or more seasonal
4 = major evacuation routes parallel to interstate, some seasonal
5 = all evacuation roûtes parallel to or are I-70 or U.S. 6

The accident data set was altered slightly with the addition of the category of "town" to the urban/rural area classification.

How to Use the Model

The computer model breaks the I-70 route into four routes: East I-70, Eisenhower Tunnel, West I-70, and Loveland Pass. Each of these routes can be examined in total or in sections. A section is determined by the choice of milepost values (in the model "milepost" is a generic term for milepoints and mileposts). Once a portion of a route is selected there are four categories of data that can be viewed:

1) accident data;
2) road condition state and maintenance summary;
3) evacuation data;
4) all variables listed by milepost.

A fifth category, general road data, is included, but the data is not currently ready for display.

Identifying Sensitive Locations

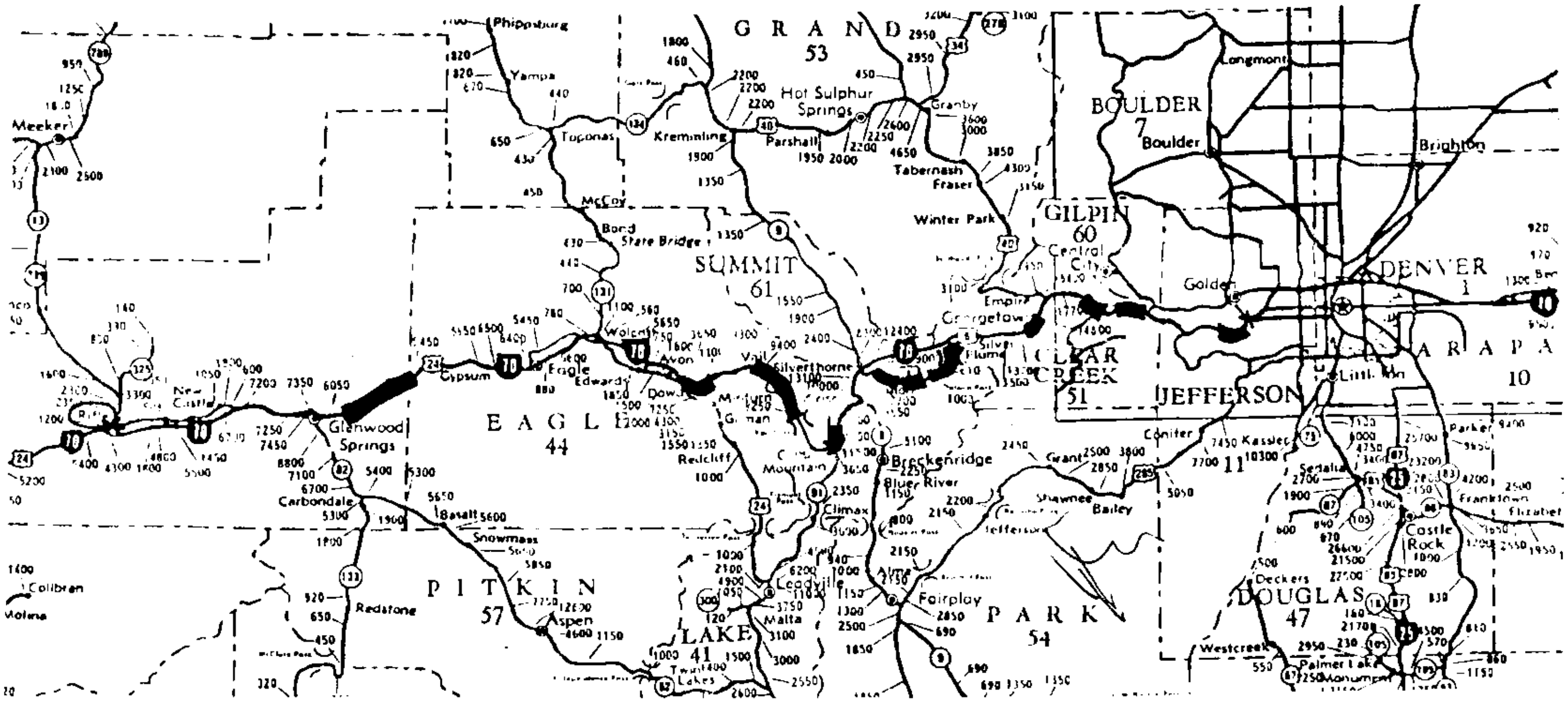
Sensitive locations are those portions of the I-70 route where any one of the three accident rates is "high" and evacuation is difficult. Emergency response and evacuation is considered difficult for any type of location except those for which evacuation routes are numerous. Evacuation poses the greatest problems for emergency personnel when the evacuation route is either I-70 or U.S. 6.

An accident rate is considered "high" based on an interpretation of State Highway Department data sheets indicating "higher" accident rates. The accident rates used to locate sensitive sections of the route are an injury rate $\geq .85 \times 10^{-6}$, a fatality rate $\geq 6.50 \times 10^{-8}$, or a total rate $\geq 3.00 \times 10^{-6}$. Sensitive locations are listed in Table 7 and shown in Figure 8.

TABLE 7

SENSITIVE LOCATIONS ON THE I-70 ROUTE: AN EXAMPLE USING 1983 DATA

milepoint	accident rates injury	fatal	total	evacuation ADT	population	access
	$x10^{-6}$	$x10^{-8}$	$x10^{-6}$			
EAST70						
258.614 (to 256.018)	.83	6.60	1.82	33,200	5442	parallel/=
244.283 (to 241.381)	.79	.00	3.13	24,200	0	limited
239.695 (to 238.935)	1.11	.00	2.59	22,200	515	limited
227.924 (to 225.650)	.48	6.89	2.20	17,300	515	limited
LOVELAND PASS						
228.733 (to 224.884)	2.14	.00	3.20	1,350	25	limited
224.884 (to 216.497)	1.21	.00	2.42	1,350	0	US 6
216.497 (to 215.220)	2.01	.00	4.68	3,150	300	US 6
214.620 (to 213.417)	1.00	.00	2.01	8,400	200	US 6
211.740 (to 210.940)	1.56	.00	1.87	8,800	225	US 6
WEST70						
197.859 (to 195.252)	.63	9.06	1.72	12,600	0	parallel/=
189.963 (to 179.857)	.85	5.32	2.93	10,000	0	parallel/=
173.310 (to 171.237)	.40	6.69	2.21	19,500	752	parallel/=
171.237 (to 168.778)	.88	.00	2.63	12,800	830	limited
130.950 (to 121.500)	.70	13.95	2.56	6,200	0	parallel/=



Sensitive area

FIGURE 8

SENSITIVE LOCATIONS AS DETERMINED BY COMPUTER MODEL

CONCLUSIONS

This paper has explored a number of themes in varying levels of detail, and it may be useful to summarize the main points. In the first instance, the argument above has emphasized the importance of examining the HLNW tranportation question, both as a central factor within the management of nuclear materials, and as an issue with dynamic political and policy overtones. Second, and following on from the first statement, we have argued that if hazardous materials are to be transported around the country, then it is important that close attention be paid to the ways in which the population assesses risk and interprets the dangers that they believe themselves to be facing. Third, and perhaps most important, we have also demonstrated that the successful management of material transport lies in the understanding of local issues, local conditions, and local circumstances. As we have shown at length in the various Colorado examples, the successful management of accidents and possible evacuations lies with the personnel who possess such localized knowledge.

These conclusions may not seem particularly startling or insightful; after all, it is the very basis of emergency management to manage accidents within the local context. However, and as we have shown at length within this paper, there is a fundamental tension within the way in which the nuclear waste transport process is managed. That tension lies with the imposition of routes and regulations by the federal government upon lower levels of political organization--an imposition which places particular burdens upon the latter but which provides little in the way of material support. As we have seen, federal agencies dictate the principles of routing, but provide little in the way of control of the trucking industry. In terms of the examples that we have explored in this paper, this control of the movement of HLNW at the federal level removes from the lower levels of organization the ability to manage hazardous materials in the most effective manner, because it limits their ability to choose local routes which may be of lower objective quality, but which are easier to deal with in times of emergency.

We are, of course, aware of the reasons that lie behind federal preemption--namely the concern that local jurisdictions will play some game of "Not in My Back Yard" if they are permitted to determine the routing question. This does however miss the point that we have been at pains to eleborate within this paper--namely that the present system of preemption is capable of creating a great deal of political opposition to the management of waste in general and its transport in particular. That is to say, the inability to control routing may well produce a climate within which large numbers of residents become opposed to the transport of HLNW, because they receive no satisfactory assurances that the transportation can be effectively managed, and because they see no benefits to their own communities. In such situations, it seems very likely that general opposition to nuclear waste transport could readily become another aspect of a more specific and widespread opposition to nuclear power. We do not want in this paper to comment on the desirability or otherwise of nuclear power, but we do want to emphasize the vulnerability of this sector in light of the problems facing the transportation of high-level nuclear waste materials.