Planning for a Transportation-Related Hazardous Material Spill in a Municipal Watershed

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ABSTRACT

Because of urban sprawl, the formerly isolated water supplies of many municipalities are now exposed to transportation-related hazardous material spills. This study uses the water supply in Worcester, Massachusetts, as a model to identify factors associated with the risk of a transportation-related hazardous spill and to assess the current response to a spill. Business and industry within the watershed were surveyed to determine the most probable types of hazardous materials being transported. Local police records were used to identify sites with a high frequency of accidents. Local officials were surveyed to determine the probable response to a spill. It is concluded that governmental infrastructure problems may prevent an adequate response in those sections of the watershed outside the municipal boundaries. Recommendations are made to eliminate some of these deficiencies.

During the past quarter century urban populations have shifted into the suburbs and even more distant rural areas. Improved highway access, including construction of the Interstate highway system, has played a most important role in this decentralization. The ease of access to suburban and rural environments is often an important factor in siting new industries there.

The watersheds of many once-rural upland surface water supplies are now traveled by vehicles carrying a myriad of hazardous materials. Transportation-related accidental spills of hazardous materials pose an important threat to many potable water supplies (1-4), and there have been many instances in which drinking water was contaminated by hazardous material spills. Only recently have hazardous material spills begun to be properly reported. Since 1980 comprehensive records have been maintained by only one New England state, Connecticut. Based on Connecticut data, it was estimated that the Region I office of the U.S. Environmental Protection Agency (EPA) received reports of only 7 percent of all transportation-related hazardous material spills in New England during 1980-1981, although 60 percent of the severe spills (more than 100 gal) were reported (1).

In an attempt to determine the vulnerability of a surface water supply to an accidental transportation-related hazardous material spill, the watershed serving the city of Worcester, Massachusetts, was studied to identify possibilities for a transportation-related hazardous material spill, to determine the current response procedure to a hazardous material spill, and to recommend additional procedures that municipal agencies might take to prevent and minimize the environmental impact of a spill in a sensitive watershed. The study was carried out by the Water Quality Resource Study Group (WQRSG) (5), made up of environmental professionals from four city departments, regional environmental and planning groups, and faculty of the colleges and universities of the Worcester Consortium for Higher Education. Since 1972 the WQRSG has combined research, public service, and education to solve many water-related problems in central Massachusetts.

This study uses the Worcester watershed as an example to

1. Demonstrate the value of surveying the businesses and industries within the reservoir watershed in order to identify the types of hazardous materials likely to be used and thus transported within watershed boundaries;
2. Locate the most probable sites for possible transportation-related spills by studying traffic accident patterns;
3. Identify local, state, and federal experts and resources and to assess their abilities to react to the occurrence of a hazardous material spill;
4. Examine state and federal laws and regulations that affect the reporting, cleanup, and compensation for a hazardous material spill; and
5. Make recommendations that would serve to reduce the possibility of a spill in a watershed and to minimize the impact of such a spill once it had occurred.

THE WORCESTER WATERSHED

The Worcester watershed (Figure 1) encompasses approximately 40 miles^2 and is located almost entirely outside the jurisdictional limits of the central city in five surrounding communities (Holden, Paxton, Rutland, Princeton, and Leicester). For reference, the large body of water shown in Figure 1 north of Worcester and east of Holden is Wachusett Reservoir, which supplies Boston. The 10 reservoirs, each with a capacity between 15 million and 3 billion gal, store a total of 6.65 billion gal of water. The system is geographically separated into two distinct watersheds that adjoin each other. Chlorine disinfection is the only treatment to the water before it enters the distribution system. About 35 miles of state routes and major roadways are located within the watershed boundaries. In addition the watershed is traversed by numerous residential streets and private roads. There are no major industrial zones within the watershed. However, several commercial and small industrial users of hazardous materials such as plastic manufacturing plants, machine shops, gasoline service stations, and fuel oil distribution plants are located within the watershed.

USERS OF HAZARDOUS MATERIALS

Businesses in the Worcester watershed were identified by using the Directory of Massachusetts Manufacturers, 1980-1981, and the Yellow Pages of the central Massachusetts telephone directory. Groups of

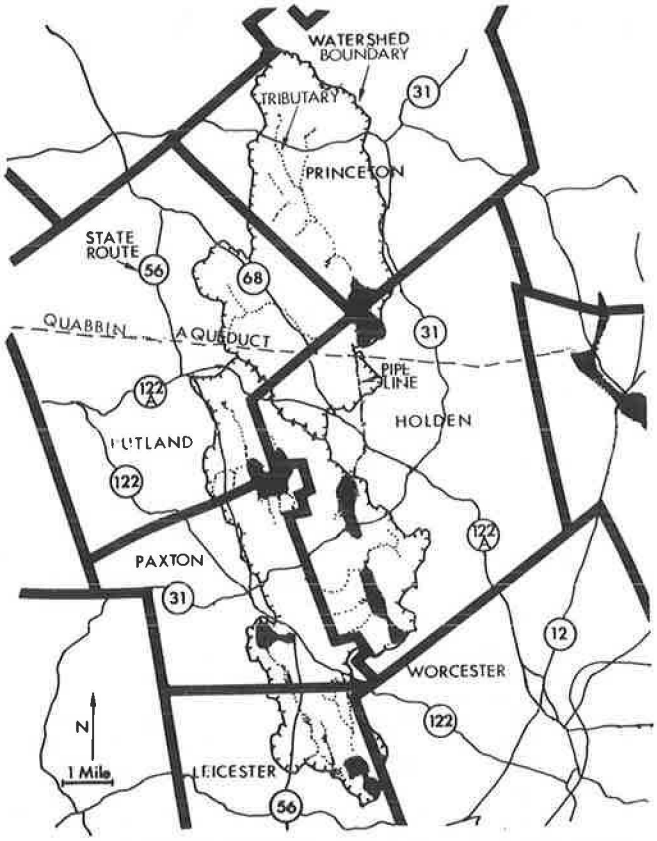

FIGURE 1 The Worcester, Massachusetts, watershed (bodies of water indicated by shading).

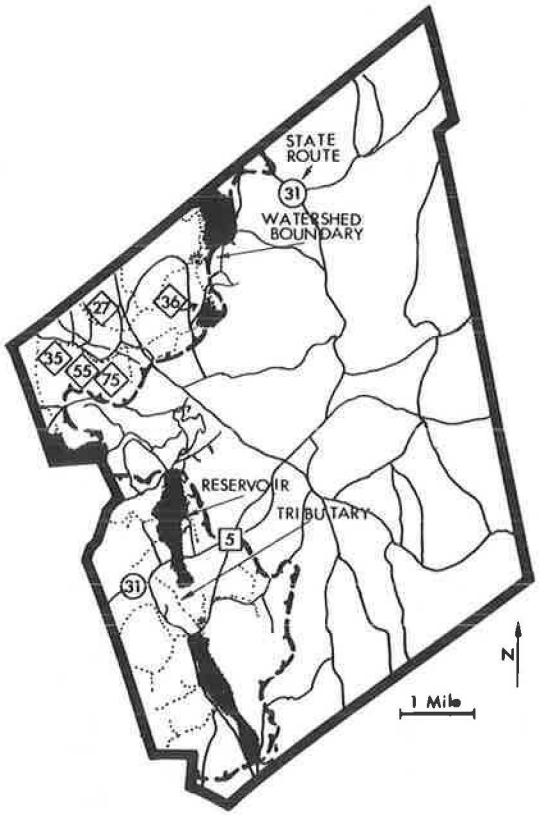

FIGURE 2 Worcester watershed in the town of Holden.

chemicals likely to be used by those companies were obtained from the Directory of Massachusetts Manufacturers according to the standard industrial classification (SIC) code for each business. Eliminated from consideration were businesses that would not be likely to use chemicals or petroleum products in a sufficient quantity to pose the risk of a transportation-related spill (e.g., general contractors, dairy farms, coin laundries). Figure 2 shows this analysis for the town of Holden. The Worcester watershed occupies a substantial part of the eastern boundary of Holden. Within Holden a major service road and state routes 122A and 31 pass through the watershed. Businesses within the watershed likely to use hazardous materials are designated on the map by a diamond-shaped symbol containing the appropriate SIC number. The majority of hazardous materials include oils, plating wastes and sludges, gasoline and diesel fuel, and trichloroethylene. The single site with a high frequency of accidents in Holden is indicated by a square symbol in which the number of accidents that have occurred there is contained.

This procedure was repeated for each of the other four towns in which the watershed is located (Table 1). Based on SIC designations, the hazardous materials used by businesses in the watershed are likely to be fuel and diesel oil, gasoline, and solvents used in electronics and metal fabrication. The businesses use these materials in various manufacturing processes and also sell them commercially. Similar materials were used by businesses just outside the watershed boundaries.

Fuel oil storage and a town landfill were located within a few yards of the watershed boundary in Leicester. State route 56 is located within the watershed and close to several reservoirs in that town. In Paxton (Figure 3) three gasoline stations are located within the watershed, and three major state routes (122, 56, and 31) are located in the watershed. A fuel oil company and several industries (SIC code 36) are also situated within the watershed in the town of Princeton, and the Boston and Maine Railroad right-of-way bisects the watershed in that town. State routes 31 and 62 are also found in the watershed in Princeton. The most important feature in Rutland is state route 122A, which passes through the watershed.

Throughout the watershed in all communities, residential communities are found in large numbers. Thus virtually all roads in the watershed are traveled by fuel oil trucks.

TABLE 1 Hazardous Material Use in Watershed

Town	SIC No.	No. of Businesses in Watershed	Possible Hazardous Material
Holden	27	2	Inks, dyes
	35, 36	7	Oils, plating wastes, sludges
	55, 75	1	Gasoline, diesel fuel, oil
Leicester		1	Fuel oil (dealer)
Paxton	17	4	Fuels and oils associated with construction machinery
	55, 75	2	Gasoline, diesel fuel, oil
Princeton		1	Fuel oil (dealer)
		1	Fuels and oils for buses
	36	1	Solvents, plating wastes, sludges
Rutland	17	1	Fuels and oils associated with construction machinery
	35	1	Oils, plating wastes, sludges, trichloroethylene
	75	1	Gasoline, oil, paint, trichloroethylene

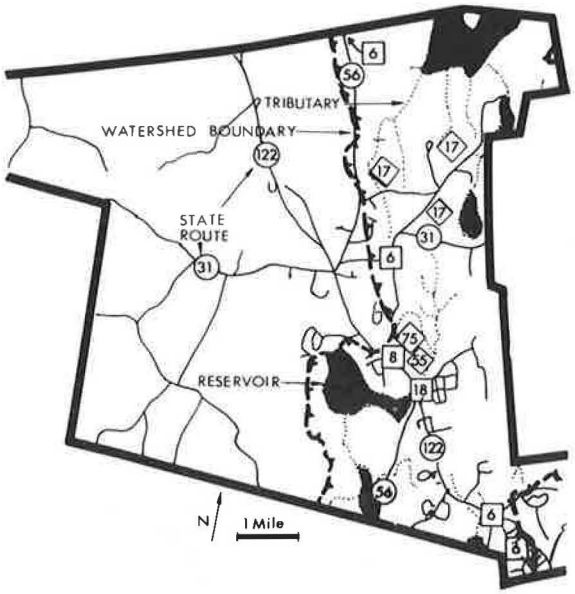

FIGURE 3 Worcester watershed in the town of Paxton (note six high-frequency accident sites).

TRAFFIC ACCIDENT FREQUENCY IN THE WATERSHED

A recent study of 123 traffic-related accidents occurring between 1972 and 1979 in which hazardous materials contaminated bodies of water in New England (6) revealed that a variety of industrial and agricultural chemicals were involved. These included petroleum products, caustic soda, dioctylphthalate, alcohol, ethylene glycol, fertilizers, latex, methyl methacrylate, acids, styrene, toluene, trichloroethylene, and xylene. Crusberg and Smith (1) recorded 306 similar events for New England for the years 1972-1981 using information obtained from EPA Region I. By comparing data obtained from Connecticut with that obtained from EPA, it was also estimated (1) that from July 1, 1980, to June 30, 1981, 77 percent of such spills were not reported to EPA. Applying the same underreporting ratio to the 1980-1981 EPA Region I data for transportation-related spills of hazardous materials in which some of the spill material entered surface waters, it was estimated that approximately 106 such incidents occurred throughout New England during that year. Such events are indeed common.

Traffic accidents involving carriers of hazardous materials represent a possible threat to the Worcester water supply because users of these materials have now been identified within the watershed. Traffic accident data were obtained from police departments in each of the five watershed towns. In most towns it was possible to obtain data for a 3-year period. For Leicester and Princeton, data were based on a 2-year period. When data were grouped by 3-month seasonal periods, the differences were not statistically significant. Data on the frequency of traffic accidents occurring in the Worcester watershed are as follows (average number of accidents per year, 74):

Town	No. of Accidents
Holden	14
Leicester	11
Paxton	23
Princeton	9
Rutland	17

The foregoing data show that traffic accidents occur relatively frequently within the Worcester watershed. To date, no accidents have occurred in which hazardous materials have been spilled in other than minor amounts. Paxton accounted for 31 percent of all accidents, and 23 percent occurred in Rutland. However, six of the nine sites with a high frequency of accidents (that had more than five accidents during the survey period) were in Paxton. Severe accidents have occurred in Paxton at the intersection of state routes 56 and 122, including seven fatalities in the last 10 years (Table 2 and Figure 3). Three of the nine sites with a high frequency of accidents are within 400 ft of a tributary to a reservoir. Four such sites in Paxton are located along state route 122. The site with the highest frequency of accidents is located only 600 ft from a major reservoir and directly adjacent to a tributary of that reservoir.

TABLE 2 Sites with High Frequency of Accidents in the Worcester Watershed

Town	No. of Accidents in 3-Year Period	Distance from Reservoir or Tributary (ft)
Holden	5	850 (R)
Leicester	9[a]	0 (T); 350 (R)
Paxton	18	0 (T); 600 (R)
Paxton	8	1,300 (R)
Paxton	6	1,300 (T); 6,600 (R)
Paxton	6	1,200 (T); 1,400 (R)
Paxton	6	1,650 (R)
Paxton-Rutland town line	6	1,700 (T); 4,000 (R)
Rutland	8	400 (T); 13,000 (R)

Note: R = reservoir; T = tributary.
[a]Based on a 2-year period.

Another location with a high frequency of accidents (nine accidents in 2 years) is in Leicester, immediately adjacent to a tributary and only 350 ft from a major reservoir. In Holden, five accidents have occurred at scattered locations on roads adjacent to reservoirs.

There are fewer accidents in Princeton, probably because of both the absence of major routes and a small population living in the watershed. The Boston and Maine railroad, which bisects the watershed in Princeton, is a route over which hazardous materials are transported. A derailment in the 1970s caused spillage of rock salt, but there was no substantial impact on the watershed.

REGULATIONS GOVERNING REPORTING OF SPILLS

There are several laws and regulations governing emergency response to hazardous material spills. The Water Pollution Control Act of 1970 (Public Law 91-224) requires reporting of spills of oils (Sec. 11B) and hazardous materials (Sec. 12 and 40 C.F.R. 117.3) to the federal government. First notice of pollution discharge must be made immediately, in accordance with 33 C.F.R. 153.203, to the National Response Center (NRC) (40 C.F.R. 1510) or alternatively to the nearest U.S. Coast Guard or EPA office. The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (Public Law 96-510), through Section 103(a), requires immediate notification to the NRC whenever there is a release of a "reportable quantity" of a hazardous substance into surface waters, navigable waters, drinking water supplies, land surfaces, and ambient

air within the United States. Reportable quantities are specified in 40 C.F.R., Part 110, for oil and Part 117 for 297 other materials. Typical reportable quantities range from 1,000 lb for benzene to 10 lb for hydrogen cyanide and 1 lb for the insecticide DDT. Other reporting provisions are contained in 40 C.F.R. 171.15. A memorandum of understanding between the NRC and the Chemical Transportation Emergency Center (CHEMTREC) was signed in 1970, making information readily available to officials at the scene of a spill through a toll-free telephone number 24 hr a day.

The NRC also serves as initiator of a chain of notification steps that set federal response plans into action (7). Local response to a spill in New England is coordinated through the EPA Region I office for inland waters and the Coast Guard for navigable or marine waters. Criminal penalties exist for noncompliance.

Should a federal response be required, a regional response team (RRT) consisting in Massachusetts of officials of EPA and the Massachusetts Department of Environmental Quality Engineering (DEQE) and headed by one federal official (the on-site coordinator) must ensure proper removal of any spilled material. If necessary, federal money may be used to ensure that removal of hazardous materials is completed in the event that the responsible party cannot be identified or will not take appropriate action (Federal Water Pollution Control Act of 1972, Sec. 311, Subsection K; 33 C.F.R. 153.401-153.419). Under certain circumstances state or even local officials may also authorize removal of spilled materials and receive reimbursement. Costs of replacing or restoring resources damaged by pollution are not covered by this law.

In Massachusetts reporting of oil and hazardous material spills must be made in accordance with Chapter 21, Section 27, Clause 14 of the General Laws, which also provides criminal penalties for noncompliance. The discharger is liable to the Commonwealth for all costs incurred by the Commonwealth in containing and removing oil and hazardous material spills and also for the costs of restoring damaged areas to their original condition. Double damages may be assessed under Chapter 91, Section 59A of the General Laws against a party who negligently discharges oil onto or into the waters of another party. In Massachusetts cleanup of a hazardous material spill must be performed by a licensed contractor.

Related Massachusetts laws pertaining to response to hazardous material spills include Chapter 48, Section 59A, which encourages mutual aid, and Chapter 639 of the Acts of 1950, which established Civil Defense. Section 14 of that act also allows mutual aid in the event of a disaster.

LOCAL RESPONSE TO A HAZARDOUS MATERIAL SPILL

Interviews were conducted with the police and fire chiefs of all five towns in which the Worcester watershed is located to determine the response procedure that would be followed in the event of a spill. In each town, the fire chief identified himself as the person in charge of hazardous spills. Table 3 gives the responses to that interview, giving a tentative plan by each chief as to how he would proceed should a spill occur in the watershed area under his jurisdiction. None of the chiefs were aware of the precise boundaries of the watershed in their respective town. It is apparent that no common plan exists among the various town officials. The interviews revealed that all fire chiefs were trained in tactics of dealing with hazardous material spills. However, other firefighters may not be as aware of those tactics because of lack of training. Many of the local fire departments consist mainly or entirely of volunteers trained only in the essentials of firefighting. These interviews also revealed that equipment used to clean up spills was not available in the region. In addition only the city of Worcester had conducted simulation training for responding to a hazardous material spill. The Worcester fire department has protective clothing and air masks tethered to an emergency vehicle for use in these situations.

TABLE 3 Response Sequence Suggested by Fire Officials in Worcester Watershed Towns

Response from Fire Official[a]	Town A	B	C	D	E
CHEMTREC	1	2	1	1	1
Massachusetts DEQE	3	1	2	–	2
Worcester water bureau	4	–	–	2	3
U.S. Coast Guard	–	–	–	4	–
Town highway department	2	–	–	–	–
Cleanup company	–	–	4	3	–
State police	–	–	–	5	–
Worcester fire department	–	3	3	–	–
Company responsible for spill	5	–	–	–	–

Note: Numbers indicate sequence in which each town would respond to a hazardous material spill.

[a]In order of contact.

The proper sequence of events following a spill would include notification of Massachusetts DEQE, which would send an Incident Response Team (IRT) to the scene of the accidental discharge. This team represents the state's contribution to the RRT. The identity of the responsible party is then made, and it is next determined whether that party will assume responsibility for cleanup; if not, the state intercedes and assumes that responsibility. The role of the RRT is advisory, because the local fire chief retains total control during the entire cleanup operation. Federal response would only be initiated for large spills. Usually state response in Massachusetts is quite efficient, because the state DEQE maintains four regional offices. However, there are also four separate phone numbers, and on holidays, nights, and weekends another phone number is used. In contrast, the states of Vermont and Maine maintain a single statewide emergency response telephone number 24 hr a day. The EPA Region I response is authorized from an office near Boston.

It was estimated that a minimum of 2 hr would elapse between the time a spill event occurred and arrival of a cleanup company at the scene (Table 4). An analysis of the Somerville, Massachusetts, spill of phosphorus trichloride (8) on April 3, 1980,

TABLE 4 Estimated Minimal Time for Response to Hazardous Material Spill in Watershed

Response	Minimal Time for Completion (min) By Response	Cumulative
Accident reported	5	5
Fire chief arrives at site	10	15
Site inspection (hazardous materials identified)	5	20
CHEMTREC notified	5	25
Massachusetts DEQE and U.S. Coast Guard notified	10	35
Company responsible for spill notified	10	45
Cleanup company notified	10	55
Cleanup company arrives at site	60	115

demonstrated that 3 hr was required before cleanup could actually begin and that technical information provided to local authorities only aggravated the already dangerous conditions at the accident scene. A spill occurring near a reservoir or one of its tributaries would require an immediate response in terms of containment before cleanup. Unfortunately, at this time no resources are available in the Worcester region to effect such a response nor are trained personnel nearby to supervise and carry out such an effort. Storm drains in major roadways were designed to minimize turbidity entering the reservoirs, but no consideration was given to minimizing the impact of a hazardous material spill by retarding its passage with retention barriers.

DISCUSSION

Decades ago the city of Worcester and many other large communities in the United States built reservoirs and purchased lands to protect their drinking water supplies. The recent decentralization of the urban environment has led to extensive commercial, industrial, and residential development of once well-protected upland watersheds. This development has increased the possibility of transportation-related hazardous material spills within these formerly isolated watersheds. A serious governmental infrastructure problem exists in those cases in which the watershed lies outside the municipal boundaries.

This study identified several deficiencies in the emergency response that would occur if a hazardous material were spilled within the Worcester watershed. Officials from suburban or rural communities outside Worcester would be in charge of the cleanup operation. Although the officials in charge had received some training in handling the spills of hazardous materials, they did not appreciate the special problems that would arise in the case of a spill within the watershed. Many officials were unsure of the exact watershed boundaries or the types of hazardous materials transported through the watershed. They also had no contingency plans for dealing with an accident involving hazardous materials within the watershed. The majority of firefighters in the suburbs and rural towns surrounding Worcester are volunteers and may lack training in hazardous material spills. There is virtually no equipment that can be made available quickly to abate a spill in the watershed. Most fire chiefs indicated that they would rely on the state DEQE to obtain the necessary materials and equipment. It is clear that considerable time would pass before an adequate response was undertaken.

The Transportation Research Board (9) has noted unresolved issues related to hazardous material transport. One issue, which could not be considered in this study, was the need for adequate training of personnel involved in handling hazardous materials. Another issue, the knowledge of geologic conditions in the vicinity of a spill, should be the responsibility of both town engineers or public works officials and those city officials who must continuously monitor the watershed. Many suggestions have been made in the literature for dealing with hazardous material spills (10-13), and a contingency plan has been published by EPA (14). Canadian officials have also given much thought to hazardous material transport (15), and their observations and conclusions essentially parallel those of their U.S. colleagues.

In 1981 the city of Worcester developed, in outline form, a plan to give some direction in dealing with a transportation-related hazardous material spill within its own boundaries, but should a spill occur in its watershed, much of that plan would not apply.

The studies reported here indicate that it is relatively easy to identify the sites with a high frequency of accidents within the watershed at which a spill would pose an immediate threat to a reservoir. It would not be difficult to undertake contingency planning for each of these sites. In many cases relatively inexpensive road drainage reconstruction projects could provide temporary containment of hazardous material spills.

Identifying potential users of hazardous materials within a watershed is a valuable aid in identifying the type of materials likely to be spilled on local secondary roads. Traffic surveys on major routes would help identify materials routinely passing through the watershed. It is possible to estimate the amount of hazardous material released en route through the Worcester watershed by using the data and method of Abkowitz et al. given in another paper in this Record. Their results indicate that the expected fraction released per mile shipped ranges from approximately 1×10^{-8} to 8×10^{-6}, depending on the container class. These small amounts pose an interesting problem for a municipality trying to arrange its priorities for allocating resources. A catastrophic spill may be extremely rare and may even be virtually impossible to guard against in a remote rural watershed. Yet readiness through thoughtful planning may lessen the impact should a spill occur and threaten a public water supply.

It appears clear that the municipality deriving its water from the watershed must take the lead in solving the governmental infrastructure problem. The smaller surrounding communities have little incentive to use their resources to develop plans that would reduce the effect of a hazardous material spill on the larger municipality.

The central city must work with towns in which its watershed is located to establish a common plan of action regarding notification of central city officials, prevention, and cleanup of hazardous material spills. Exact locations of watershed boundaries should be made known to emergency personnel in all communities in which the watershed is located. Signs could be placed on local roads to identify watershed boundaries. Worcester may be unique in that virtually none of its reservoirs or watershed is under its own jurisdiction.

The central city should consider the purchase of supplies and equipment that could be used to abate any hazardous material spill immediately. Training in placement of such materials and operation of equipment and other aspects of mutual aid that could benefit all communities in which the watershed is located should be undertaken.

New road construction and road reconstruction projects within the watershed should include engineering measures that would prevent or contain hazardous material spills. Sites with a high frequency of accidents might be reconstructed solely for that purpose. Under certain conditions transport of hazardous materials across certain roads in a watershed might be prohibited.

On a larger scale, states should establish a single statewide emergency response telephone number that is available 24 hr a day.

CONCLUSIONS

Transportation-related spills of hazardous materials pose a small but nevertheless real threat to public drinking water supplies. Using the watershed of the city of Worcester as a model, numerous deficiencies

have been identified that would prevent normal interception of a spill that could threaten a city water supply. Many of the deficiencies result from the need of the central city to rely heavily on other towns to respond to a threat to its water supply. Numerous remedies have been suggested to correct the deficiencies noted. This planning process and analysis of a municipal watershed model should have application to many other communities in which water supplies are subject to urban and suburban development.

ACKNOWLEDGMENT

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