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APPENDIX A

SPECIFIC DATA NEEDS FOR ROUTE COMPARISON FACTORS

Source: DOT, 1984a

Primary Route Comparison Factors

Normal Radiation Exposure

This dosage is calculated using the cumulative dose to: persons residing along the route, passengers in other vehicles, the truck crew, and people at the truck stops where the hauler stops. Population density is calculated using a zero to five mile band along the route.

Persons residing along the route.

DATA: average population density (people/sq. mi.)
length of route (miles)
average vehicle speed (mph)

Passengers in other vehicles.

DATA: length of route
average traffic count (vehicles/hr)
average vehicle speed
distance between opposing traffic lanes (ft)
vehicle separation distance (ft)

Truck crew.

DATA: length of route
average vehicle speed

People at truck stops.

DATA: length of route
average vehicle speed

Public Health Risks from Accidents

These risks are calculated using the release frequency and accident consequence. The best overall indicator of accident frequency is the accident rate since it is the preferred inherent component of accident frequency. The accident's consequences will have many identical factors for the two alternate routes (e.g. atmospheric conditions, quantity and type of material being transported). The population exposed to radioactivity is determined using an approximately 25 square mile area from any given point along a route. The level of detail for each analysis can vary with the type of analysis being performed; that is where the routes travel. A five mile band with a multiplier of 1.0 would be best for an urban area. Health consequence band multipliers of 0.75 and 0.25 could be used for urban and rural areas respectively. The overall accident risk factor for any given route will be the product of the release frequency and the accident consequence numbers.

Accident release frequency.

These are listed in decreasing order of desirability.

DATA: #1. accident rate
#2. hazardous material truck driver fatality rate
#3. general truck driver fatality rate
#4. hazardous material truck fatality accident rate
#5. general truck fatality accident rate
#6. general vehicle traffic fatality rate
#7. general traffic accident rate
#8. accident rate predictive models
#9. length of route

Accident consequence.
DATA: population
maps
census data
health consequence

Economic Risk from Accidents

Economic risk is calculated using two measures: accident release frequency and economic-release consequence measure. The same accident rate used to determine the public health risk must be used in this instance.

Economic-release consequence measure.
DATA: type of property along route
1. farmland
2. residential
3. single family
4. multi-family
5. commercial
6. parks
7. public areas

NOTE: The 0-5 mile and 5-10 mile bands used each have consequence multipliers for each land use type that are proportional to the decontamination costs for each land use type.

Secondary Route Comparison Factors

Emergency Response

The primary factors influencing the effectiveness of emergency response are: personnel, timing, planning, and equipment. These factors are all location dependent. First order response typically takes a few minutes while secondary response requires minutes to hours to accomplish. Secondary response depends on preplanning, equipment availability, and the distance to be traveled. It is not necessary to exactly determine these parameters as routes can be compared using relative rankings that are based on arbitrarily established scales.

First order response.
1. get first responders to site
2. control immediate area
3. determine nature of hazard

Secondary response.
1. contact specialized technical personnel
2. get radiation monitoring equipment to site
3. get cleanup equipment to site

EXAMPLE. Establish scales for: response time, equipment availability, personnel hazardous material training, personnel availability. Sum these rankings to get the area total. Rank using a scale of 1 to 3 by land use type: city, town, rural, industrial.

Evacuation

Numerous factors contribute to an effective evacuation. These factors are ranked using a system which compares routes, as was done for emergency response. This approach is subjective and is intended for use only as a starting point for each route selection case. The scales and relative ranking of land use types are adjusted to fit each case.

Factors.

1. land use type
2. means of egress from structures/vehicles
3. level of pre-accident planning
4. effectiveness with which authorities implement response plans
5. nature of the threat
6. communication of need to evacuate
7. numbers of personnel needed
8. population density of the area (more difficult in low density areas resulting in longer evacuation times)
9. routes available for private autos from site (most common means of evacuation)
10. special facilities (detailed plans essential to minimize injuries and confusion)

EXAMPLE. Establish scales for number of people affected, availability and capacity of egress routes, availability of evacuation coordination personnel, time required for effective evacuation, impacts of evacuation on affected population. Rank, except for population, using scale of 1 to 3 by land use type: rural, suburban, urban, commercial, industrial. Sum ranks by land use type to get ranking factors. Multiply the ranking factor and the fraction of land use type within five miles of the route, for each land use type. Overall comparison factor is the sum of these products.

Special Facilities

These are localized areas having sufficient economic or public safety importance to require special consideration. They are unique and vital to local communities and include: schools, hospitals, prisons, nursing homes, churches, stadiums, and theaters. Parameters are determined and ranked for the routes being compared. In general, only those facilities within five miles of a route are considered.

Parameters.

1. radiation dose sensitivity of persons normally in facility
2. economic importance to local community
3. difficulty of evacuating people from facility

EXAMPLE. Factors to be assessed are dose response, economics, accident evacuation (the latter based on the parameters). Ranked using scale of 1 to 5 for each type of special facility. The sum of the rankings equals the overall facility factor for each type of facility. Compare routes by multiplying each facility factor by number of facilities along the route.

Traffic Fatalities and Injuries

Straightforward numerical estimates are needed for comparing routes. The easiest measure to use is fatalities and injuries per mile.

APPENDIX B

WORKSHEETS FOR APPLYING ROUTING GUIDELINES

Source: DOT, 1984a

A. Descriptive Data for Route

B. Normal Transport Exposure

C. Public Health Risk

D. Economic Risk

E. Emergency Response and Evacuation

F. Special Facilities

G. Traffic Fatalities/Injuries

H. Route Comparisons

A. DESCRIPTIVE DATA FOR ROUTE ___

ROUTE IDENTIFICATION:

TOTAL DISTANCE:

Accident Unit:_____

Segment	End-Points	Length	Average Speed	Pop.Count 0-5 Mile	Pop.Count 5-10 Mile	Daily Traffic Count	Daily Truck Count	Annual No. of _____	Accident Rate per _____	Accident Rate per _____

DESCRIPTIVE DATA FOR ROUTE ___

ROUTE IDENTIFICATION:

TOTAL DISTANCE:

Accident Unit:_____

Segment	End-Points	Length	Average Speed	Pop.Count 0-5 Mile	Pop.Count 5-10 Mile	Daily Traffic Count	Daily Truck Count	Annual No. of _____	Accident Rate per _____	Accident Rate per _____

WORKSHEET ___ ROUTE ___ Sheet __ of __

B. NORMAL TRANSPORT EXPOSURE

$$D = \frac{PL}{v} C_1 + \frac{LT}{v^2} C_2 + \frac{LT}{v^3} C_3 + \frac{L}{v}$$

Segment 1

P =

L =

v =

T =

D_1 = _____

$C_1 = 6.7 \times 10^{-5}$

Avg Dist Opposing Lanes =

C_2 (Table 3.2-1) =

Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

Segment 2

P =

L =

v =

T =

D_2 = _____

$C_1 = 6.7 \times 10^{-5}$

Avg Dist Opposing Lanes =

C_2 (Table 3.2-1) =

Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

Segment 3

P =

L =

v =

T =

D_3 = _____

$C_1 = 6.7 \times 10^{-5}$

Avg Dist Opposing Lanes =

C_2 (Table 3.2-1) =

Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

Segment 4

P =

L =

v =

T =

D_4 = _____

$C_1 = 6.7 \times 10^{-5}$

Avg Dist Opposing Lanes =

C_2 (Table 3.2-1) =

Avg Veh Separation Dist =

C_3 (Table 3.2-1) =

ROUTE TOTAL $D_1 + D_2 + D_3 + D_4$ =

WORKSHEET ___ ROUTE ___ Sheet __ of __

C. PUBLIC HEALTH RISK

Release Consequence

	0-5 Mile Band				5-10 Mile Band			
Segment	Pop.Count	Multiplier		Total	Pop.Count	Multiplier		Total
1	_____	x .75	=	____	_____	x .25	=	____
2	_____	x .75	=	____	_____	x .25	=	____
3	_____	x .75	=	____	_____	x .25	=	____
4	_____	x .75	=	____	_____	x .25	=	____

SUMMARY

Segment	0-5 mi		5-10 mi		Public Health Conseq Factor		AccProb (Acc Rate)		Segment Health Risk
1	_____	+	_____	=	_____	x	_____	=	_____
2	_____	+	_____	=	_____	x	_____	=	_____
3	_____	+	_____	=	_____	x	_____	=	_____
4	_____	+	_____	=	_____	x	_____	=	_____

ROUTE TOTAL _____

WORKSHEET ___ ROUTE ___ Sheet 1 of 2

D. ECONOMIC RISK

0-5 Mile Band	Segment 1				Segment 2			
Land Use Type	Area	Weight		Weighted Total	Area	Weight		Weighted Total
Farmland	___	x .01	=	___	___	x .01	=	___
Single Family Residential	___	x .10	=	___	___	x .10	=	___
Multi-Family Residential	___	x 2.00	=	___	___	x 2.00	=	___
Commercial	___	x .15	=	___	___	x .15	=	___
Parks	___	x .03	=	___	___	x .03	=	___
Public Areas	___	x .05	=	___	___	x .05	=	___
TOTALS								

0-5 Mile Band	Segment 3				Segment 4			
Land Use Type	Area	Weight		Weighted Total	Area	Weight		Weighted Total
Farmland	___	x .01	=	___	___	x .01	=	___
Single Family Residential	___	x .10	=	___	___	x .10	=	___
Multi-Family Residential	___	x 2.00	=	___	___	x 2.00	=	___
Commercial	___	x .15	=	___	___	x .15	=	___
Parks	___	x .03	=	___	___	x .03	=	___
Public Areas	___	x .05	=	___	___	x .05	=	___
TOTALS								

SUMMARY

Segment	0-5 Mile		(From Page 2) 5-10 Mile		Econ Conseq Factor		Econ Prob (Acc Rate)		Segment Econ Risk
1	___	+	___	=	___	x	___	=	___
2	___	+	___	=	___	x	___	=	___
3	___	+	___	=	___	x	___	=	___
4	___	+	___	=	___	x	___	=	___

Route Total ___

WORKSHEET ___ ROUTE ___ Sheet 2 of 2

D. ECONOMIC RISK (cont.)

5-10 Mile Band	Segment 1				Segment 2			
Land Use Type	Area	Weight		Weighted Total	Area	Weight		Weighted Total
Farmland	____	x .001	=	_____	____	x .001	=	_____
Single Family Residential	____	x .04	=	_____	____	x .04	=	_____
Multi-Family Residential	____	x .20	=	_____	____	x .20	=	_____
Commercial	____	x .01	=	_____	____	x .01	=	_____
Parks	____	x .02	=	_____	____	x .02	=	_____
Public Areas	____	x .05	=	_____	____	x .05	=	_____
TOTALS								

5-10 Mile Band	Segment 3				Segment 4			
Land Use Type	Area	Weight		Weighted Total	Area	Weight		Weighted Total
Farmland	____	x .001	=	_____	____	x .001	=	_____
Single Family Residential	____	x .04	=	_____	____	x .04	=	_____
Multi-Family Residential	____	x .20	=	_____	____	x .20	=	_____
Commercial	____	x .01	=	_____	____	x .01	=	_____
Parks	____	x .02	=	_____	____	x .02	=	_____
Public Areas	____	x .05	=	_____	____	x .05	=	_____
TOTALS								

WORKSHEET ___ ROUTE ___ Sheet __ of __

E. EMERGENCY RESPONSE AND EVACUATION

EMERGENCY RESPONSE

Land Development Type	Area in 0-5 mi band Seg 1	Seg 2	Seg 3	Seg 4	Total	Route Fraction	Weight	Weight Total
City	___	___	___	___	___	___	x ___	= ___
Town	___	___	___	___	___	___	x ___	= ___
Rural	___	___	___	___	___	___	x ___	= ___
Industrial	___	___	___	___	___	___	x ___	= ___
							(Total) Comparison Factor	___

EVACUATION

Land Development Type	Area in 0-5 mi band Seg 1	Seg 2	Seg 3	Seg 4	Total	Route Fraction	Weight	Weight Total
Rural	___	___	___	___	___	___	x ___	= ___
Suburban	___	___	___	___	___	___	x ___	= ___
Urban	___	___	___	___	___	___	x ___	= ___
Commercial	___	___	___	___	___	___	x ___	= ___
Industrial	___	___	___	___	___	___	x ___	= ___
							(Total) Comparison Factor	___

WORKSHEET ___ ROUTE __ Sheet __ of __

F. SPECIAL FACILITIES

Type of Facility	Number of Facilities		Weighting Factor (Table 3.2-6)		Total
Children's Hospital	_____	x	_____	=	_____
Hospital	_____	x	_____	=	_____
Prison	_____	x	_____	=	_____
Nursing Home	_____	x	_____	=	_____
School	_____	x	_____	=	_____
Church	_____	x	_____	=	_____
Stadium	_____	x	_____	=	_____
Shopping Center	_____	x	_____	=	_____
Theater	_____	x	_____	=	_____

(Total)
Comparison Factor _____

WORKSHEET ___ ROUTE __ Sheet __ of __

G. TRAFFIC FATALITIES/INJURIES

Accident unit of measure: _____

Segment	Segment Accident Rate		Segment Mileage		Total
1	_____	x	_____	=	_____
2	_____	x	_____	=	_____
3	_____	x	_____	=	_____
4	_____	x	_____	=	_____

(Total)
Comparison Factor _____

WORKSHEET ___ Sheet __ of __

H. ROUTE COMPARISONS

PRIMARY FACTORS	FACTOR VALUES Rte____	Rte____	TOTAL FACTOR VALUES	NORMALIZED VALUES Rte____	Rte____
Normal Radiation Exposure	____	____	_____	____	____
Public Health Risk from Accidents	____	____	_____	____	____
Economic Risk from Accidents	____	____	_____	____	____
			Route Totals (FIGURE OF MERIT)	____	____

SECONDARY FACTORS	FACTOR VALUES Rte____	Rte____	TOTAL FACTOR VALUES	NORMALIZED VALUES Rte____	Rte____
Emergency Response	____	____	_____	____	____
Evacuation	____	____	_____	____	____
Special Facilities	____	____	_____	____	____
Traffic Fatalities and Injuries	____	____	_____	____	____

APPENDIX C

MINIMUM TRAINING PROGRAM FOR FIRST-ON-SCENE PERSONNEL

Source: Gunderloy et al., 1981

Basic Training

1. Fundamentals of radiation science
   - A. radioactivity defined
   - B. fundamental properties
   - C. units of measurement
2. Radiological safety
   - A. hazard assessment, including basic instrument use
   - B. defining the extent of a radioactive hazard
   - C. control techniques
3. Radioactive materials
   - A. characterization and hazards of common radionuclides
   - B. forms of common materials
   - C. handling hazards (absorption, inhalation, ingestion)
4. Review of transportation regulations governing shipment of radioactive materials by any carrier--49CFR173.389
   - A. transport groups
   - B. Type A and B quantities
   - C. special form radionuclides
   - D. package radiation level limits
   - E. package label criteria
   - F. vehicle placarding requirements
   - G. identification of nuclide shipments
   - H. special transport route requirements
   - I. evaluation of shipper documentation for hazards assessment
   - J. review and critique of selected accidents

Advanced Training

1. Review of basic nuclear science
   - A. symbols and nomenclature of the elements, nuclides, and isotopes
   - B. radioactivity
   - C. properties of particulate and electromagnetic radiation

2. Fundamentals of radiation detection
   A. instrument types
   B. instrument applications
   C. instrument limitations
3. Air sampling techniques
   A. collection of airborne particulates
   B. concentration determination
   C. air sampling in emergencies
4. Biological effects of exposure to radiation
   A. definition of dose terms
5. Radioactive materials
   A. characteristics and relative radiotoxicity of commonly transported radionuclides
   B. physical and chemical states of commonly transported radionuclides
6. Safe handling of radioisotopes
   A. radioisotope handling hazards, including absorption, inhalation, and ingestion
   B. the use of time, distance, and shielding factors for limiting exposures
   C. decontamination methods for people and for equipment
7. Review of transportation accidents that have involved radioactive materials
   A. refresher on packaging and shipping requirements
   B. causes and effects of accidents
   C. remedial actions and recovery

APPENDIX D

MAJOR I-70 ROAD CLOSURES IN THE STUDY AREA: FEBRUARY 1984 - FEBRUARY 1985

Date	Explanation
1984	
02/25	I-70 at Floyd Hill closed 3 hours for poor visibility and road conditions.
03/09	I-70 at Vail Pass closed 5 hours for poor driving conditions.
03/22	Loveland Pass closed for 26 hours for snowslides.
04/28	I-70 west of Denver closed for few hours because of snow. Loveland Pass closed for snowslide.
04/29	I-70 west of Denver closed for few hours because of snow. Loveland Pass closed for snowslide.
05/02	Loveland Pass closed for couple of hours for poor visibility.
05/16	I-70 near Vail closed for couple hours for rock and mudslides.
05/22	Loveland Pass closed 7 hours for snowslide.
05/25	I-70 in Glenwood Canyon closed 8 hours for water on highway.
05/26	I-70 at Vail closed 12 hours for rock/mudslide.
06/06	I-70 on Vail Pass closed for few hours for snowstorm.
06/07	I-70 in Glenwood Canyon closed 3 hours for rock slide.
07/24	I-70 near Georgetown closed 1 hour for rock and mudslides.
07/27	I-70 near Georgetown closed 1 hour for rock and mudslides.
08/03	I-70 at Silverthorne closed 3 hours for truck accident.
10/15	I-70 from S.H. 26 closed 13 hours for major snowstorm. I-70 at Georgetown closed at 1:37 p.m. for major snowstorm.
10/27	I-70 Silverthorne to Eisenhower Tunnel closed 3 hours for snowstorm.
11/03	Loveland Pass closed 4 hours for snowslides.
11/11	I-70 westbound closed 1/2 hour for accident in Eisenhower Tunnel.
12/12	Loveland Pass closed 7 hours for tanker truck accident.
12/18	Loveland Pass closed 1 hour for snowslide.

1985

01/20 Loveland Pass closed 2 hours for snowslide.

01/22 I-70 at Vail Pass closed 1 1/2 hours for snowslide.

01/23 Loveland Pass closed 1 hour for snowslide.

02/05 Loveland Pass closed 1 1/2 hours for snowslide.

02/10 I-70 near Edwards closed 6 hours for truck accident involving hazardous material. Loveland Pass closed 12 hours for 2 snowslides.

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