

Appendix A – Vulnerability Determination

Vulnerability Determination

Vulnerability determinations are an advanced type of hazard assessment, performed for the highest ranking hazards for Washtenaw County. The goal is to quantitatively measure the threat experienced by Washtenaw County communities. By placing a monetary value on a hazard, a cost-benefit comparison can be made: the benefit of implementing a mitigation strategy compared to the cost of the mitigation project (the value of avoided damages).

The following worksheets present the determinations for the several highest ranking hazards in the County. The worksheets are to be reviewed and used with the following in mind:

- The purpose is to produce specific information that measures the costs of an **average worst-case scenario, not the most extreme worst-case scenario**.
- The intent is **not to reach perfect accuracies, but uniformity**. There is not one methodology for determining the costs of each hazard. The MSP/EMD allows each community to creatively explore the costs a community incurs from a hazard event. Additionally, the costs attributed to each hazard are not meant to be exhaustive, but rather to capture the major costs associated with a hazard event. Constancy is produced when the same costs are applied to each hazard determination (i.e. cost of a death, cost of a housing unit).
- The results allow for **hazards to be compared with mitigation strategies** and each other through an equal unit of measurement. Caution must be used however, as incidences can vary widely and the methodology for determining cost is relatively subjective.

- The assessment **does not circumvent the hazard ranking** table. The vulnerability determinations are a useful tool for comparing costs, but cannot change the potential impacts to the population. For example, the determination results show that severe winter weather hazards have a higher total expected annual cost than tornados, however, tornados and convective weather storms are a greater threat to Washtenaw County residents (see Section 3.0 of the County Plan).

Methodology

To perform the vulnerability determinations, the following steps were taken:

1. Identification of contributing factors. Each hazard has factors that affect the final cost. For example, tornado costs vary according to the severity of tornado, the area impacted, the type of land impacted (undeveloped, developed). In contrast, a snow storm is an event with an equal impact on all communities in the County regardless of land type.
2. Identification of costs. Costs were identified based on historic data or researched values. Table 1 shows the cost schedule, including sources.
3. Calculation of the Total Estimated Annual Cost for each hazard.

Worksheets were prepared to show the figures behind each cost, and are provided on the following pages.

Appendix A – Vulnerability Determination

Table 1: Cost Schedule for Vulnerability Determinations

Standard Costs Applied to Hazard Vulnerability Estimates

Type	Costs Considered	Cost	Unit	Source
Loss of Function Costs	Economic Activity Loss per Employee	\$87	/day	FEMA
	Electric Power Loss per Resident	\$101	/day	FEMA
	Potable Water Service Loss per Resident	\$68	/day	FEMA
	Delayed vehicles	\$32	/car	FEMA
	Cars Delayed: 15' per car per mile, for 2 lanes: 705 cars	\$22,560	/event	WC
	Temporary shelter, lodging	\$400	/household	WC Red Cross
Casualties	Deaths	\$2,710,000	/person	FEMA
	Major Injuries	\$15,600	/person	FEMA
	Minor Injuries	\$1,560	/person	FEMA
Response and Clean-up Costs	Activation of Emergency Management	\$50,000	/incident	WC Est.
	Activation of HazMat Team	\$50,000	/incident	WC Est.
	Powerline Repair (100,000-200,000 people impacted by a catastrophic storm)	\$5,000,000	/day	DTE
Loss of Property	Agricultural Crops: \$2.4 per bushel of corn, 130 bushels per acre, 640 acres per mile	\$200,000	/sq mile	MSU Extension
	- scenario assumption that event occurs early in season, no crop damage			Certified Crop Insurance Adjuster in State of Michigan
	- thunderstorms tend to damage 10-12% of 1 sq mile (60 acres): \$18,720			
	Business (Building)	\$250,000	/building	WC Est.
	- Businesses in WC	25,788		US Economic Census, 1997 (2002 data due end of 04)
	- Employees in WC	242,770		US Census
	Housing Unit (median value)	\$174,300	/unit	US Census
	Cars	\$19,522	/car	BEA, Office Trans. Technologies

Abbreviations:

- *FEMA: Federal Emergency Management Agency, Public 207*
- *WC: Washtenaw County Department of Planning and Environment/Emergency Management Estimate*
- *WC Red Cross: Washtenaw County Red Cross*
- *DTE: Detroit Edison*
- *BEA: Bureau of Economic Affairs, US Department of Commerce*

Appendix A – Vulnerability Determination

Tornado

Part A: Total Expected Annual Damage							
Probability of a tornado event occurring each year	Severity Factor	Area Factor (Amt of Area Impacted)	Impacted Area	Amt of County Land	Cost (Part B)	Expected Annual Damage by Land Type	
27%	F0	30%	1.00	1. Unpopulated areas	35%	\$75,000	\$2,126
		30%	1.00	2. Low development, agricultural	44%	\$75,000	\$2,673
		30%	1.00	3. Developed, urban	21%	\$75,000	\$1,276
	F1, F2	58%	3.00	1. Unpopulated areas	35%	\$5,760,512	\$947,201
		58%	3.00	2. Low development, agricultural	44%	\$5,760,512	\$1,190,767
		58%	3.00	3. Developed, urban	21%	\$5,760,512	\$568,321
	F3, F4	12%	6.00	1. Unpopulated areas	35%	\$12,172,794	\$828,237
		12%	6.00	2. Low development, agricultural	44%	\$12,172,794	\$1,041,212
		12%	6.00	3. Developed, urban	21%	\$12,172,794	\$496,942
Total expected annual damage of this hazard:						\$5,078,755	

Part B: Breakdown of Costs	
1. Unpopulated Areas	\$75,000
Clean-up (debris, trees)	\$25,000
Activation of Emergency Management	\$50,000
2. Low Development, Agriculture (1 unit/10 acres; 64/sq mile)	\$5,760,512
Clean-up (debris, trees)	\$25,000
Activation of Emergency Management	\$50,000
Restoration of Power Lines	\$5,000,000
Loss of crop: \$0 (assumption event occurs early, no crop to damage)	\$0
Farmsteads (1 unit 100% damaged)	\$174,300
Temporary Relocation for unit	\$400
Electric Power Loss for Households (1% of total population, 322,985, at \$101/day)	\$326,124
Economic Activity Loss (1% of total employees, 136,523 at \$87/day)	\$137,888
Major injuries (3)	\$46,800
3. Developed, Urban Areas (25-unit MF; 2,560 SF homes in 1 sq mile)	\$12,172,794
Activation of EM	\$50,000
Clean-up (trees, debris)	\$25,000
Restoration of Power Lines	\$5,000,000
Impacted housing units (five homes, \$174,300 median housing unit value)	\$871,500
Loss of function, electricity, one day (1% of 322,895 people@\$101/day)	\$326,124
Temporary Relocation for 5 Units	\$2,000
Businesses: 1% of 25,788(75% in urban area), .25% of \$500,000 business	\$241,763
Loss of business activity: 1% of 242,770 total employees, 75% in urban area, at \$87/day	\$158,407
Major injuries (5)	\$78,000
Deaths (2)	\$5,420,000

Explanation of Factors (by column)

- **Probability** is determined from Washtenaw County Emergency Management 1992-2002 tornado touch-down data.
- **Severity factors** are taken from past events 1951 to 1996: 30% were F0s; 58% F1s/F2s; 12% were F3s/F4s.
- **Area factor** represents the relationship between the severity and area impacted is represented: the stronger the tornado, the greater the area impacted.
- **Amount of County land** allows for variation in costs. Land type data taken from SEMCOG's 2000 land use coverage was divided into unpopulated areas (wetlands, woodlands, grasslands, etc.), low development, agricultural (agriculture, transportation, communications and extractive operations), and developed urban areas (all residential categories, commercial, office and industrial).
- **Damages** associated as itemized under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- **Expected Annual Damage** is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Severe Winds and Lightning

Part A: Total Expected Annual Damage				
Expected number of events per year	Area	Amt of County Land Impacted	Cost (Part B)	Expected Annual Damage by Land Type
6.5	Entire County	100%	\$13,883,449	\$90,242,418
Total expected annual damage of this hazard:				\$90,242,418

Part B: Breakdown of Costs	
Costs to County - all areas	\$13,883,449
Activation of Emergency Management	\$50,000
Clean-up (debris, 10 trees @ \$800/tree)	\$8,000
Infrastructure Failure (power, economic loss, household loss for 1 day)	\$6,139,214
Loss of crop (approx. 60 acres at \$312/acre)	\$18,720
Housing Units (0.25% of total units [131,069], \$5,000/roof)	\$1,638,363
Businesses (0.25% of businesses 25,788), \$5,000/roof	\$322,350
Loss of business activity: 1% of 242,770 (25%) employees, at \$87/day	\$52,802
Major injuries: 15	\$234,000
Deaths: 2	\$5,420,000

Explanation of Factors (by column)

- Probability is determined from Washtenaw County Emergency Management 1992-2002 data. Thunderstorms that produce lightning occur approximately 7.8 times per year, windstorm events due to thunderstorms are the more conservative estimate. Amount of County land is taken as the entire County as it is not likely that one small area of the County will be impacted while the remaining land area is not. Thunderstorms generally impact all County lands equally.
- Damages associated with events in different land uses are shown under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- Expected Annual Damage is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Hailstorm

Part A: Total Expected Annual Damage							
Expected number of incidents per year	Severity Factor of Hailstorms		Area Factor (Amt of Area Impacted - connection between severity and area impacted)	Area	Amt of County Land Impacted	Cost (Part B)	Expected Annual Damage by Land Type
1	Minor	83%	1.00	1. Unpopulated areas	35%	\$75,000	\$21,875
		83%	1.00	2. Low development, agricultural	44%	\$243,510	\$88,930
		83%	1.00	3. Developed, urban	21%	\$12,648,603	\$2,204,652
	Moderate/Severe	17%	3.00	1. Unpopulated areas	35%	\$75,000	\$13,388
		17%	3.00	2. Low development, agricultural	44%	\$243,510	\$54,644
		17%	3.00	3. Developed, urban	21%	\$12,648,603	\$1,354,665
Total expected annual damage of this hazard:							\$3,738,153

Part B: Breakdown of Costs	
1. Unpopulated Areas	
Activation of Emergency Management	\$75,000
Clean-up	\$50,000
	\$25,000
2. Low Development, Agriculture	
Activation of Emergency Management	\$243,510
Clean-up	\$50,000
Loss of crop (approx. 60 acres at \$312/acre)	\$25,000
Impacted cars (25 cars, \$3,900 per car)	\$18,720
Farmstead (1 unit, 30% damaged, \$174,300 median value)	\$97,500
	\$52,290
3. Developed, Urban Areas	
Activation of Emergency Management	\$12,648,603
Clean-up	\$50,000
Power Restoration	\$25,000
Housing unit damage (1% of 131,069 units at 1% of \$174,300 median value)	\$5,000,000
Cars damage (1% of housing units at 3,900 per car)	\$2,284,533
Business (30% of one \$500,000 business)	\$5,111,691
Loss of electricity for 1 day (1% of 131,069 housing units at \$101/day)	\$45,000
	\$132,380

Explanation of Factors (by column)

- **Probability** is determined from Washtenaw County Emergency Management 1992-2002 data.
- **Severity factors** are taken from past events: 83% produce ≤ 1" hail, 17% > 1" hail.
- **Area factor** represents the relationship between the severity and area impacted is represented: the stronger the hailstorm, the greater the area impacted.
- **Amount of County land** allows for variation in costs. Land type data taken from SEMCOG's 2000 land use coverage was divided into unpopulated areas (wetlands, woodlands, grasslands, etc.), low development, agricultural (agriculture, transportation, communications and extractive operations), and developed urban areas (all residential categories, commercial, office and industrial).
- **Damage** associated with events in different land uses are shown under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- **Expected Annual Damage** is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Hazard Materials Transportation Incidents

Part A: Total Expected Annual Damage							
Expected number of incidents per year	Severity Factor - Release of Substances		Road Type	Damage Factor (Amt of Impact)	% of Commercial Vehicles	Cost (Part B)	Expected Annual Damage
16.00	Minimal damage, release	80%	Highway, State	6.00	40%	\$153,760	\$4,723,507
		80%	Primary Roads	3.00	15%	\$105,360	\$606,874
		80%	Local, subdivision or private roads	1.00	45%	\$75,940	\$437,414
	Moderate damage, release	15%	Highway, State	6.00	40%	\$96,800	\$557,568
		15%	Primary Roads	3.00	15%	\$116,800	\$126,144
		15%	Local, subdivision or private roads	1.00	45%	\$110,800	\$119,664
	Major damage, release	5%	Highway, State	6.00	40%	\$96,800	\$185,856
		5%	Primary Roads	3.00	15%	\$116,800	\$42,048
		5%	Local, subdivision or private roads	1.00	45%	\$110,800	\$39,888
Total expected annual damage of this hazard:							\$6,838,963

Part B: Breakdown of Costs	
1. Freeways and Interchanges (I-94, US-23, M-14)	\$153,760
Activation of Emergency Management	\$50,000
Activation of HazMat Team	\$50,000
Major Injuries (2)	\$31,200
Vehicle Delays (2 lanes traffic, one way)	\$22,560
2. Secondary Roads (State and Highways)	\$105,360
Activation of Emergency Management	\$50,000
Activation of HazMat Team	\$25,000
Major Injuries (1/2)	\$7,800
Vehicle Delays (one lane of traffic, two ways)	\$22,560
3. Local, Subdivision Roads	\$75,940
Activation of Emergency Management	\$50,000
Activation of HazMat Team	\$12,500
Major Injuries (1/2)	\$7,800
Vehicle Delays (one lane of traffic, two ways, 25%)	\$5,640

Explanation of Factors (by column)

- **Frequency** is determined from Washtenaw County Emergency Management (WCEM) 1992-2002 data.
- **Severity factors** are based on past incidences, WCEM data.
- **Area factor** represents the relationship between severity and impact: more severe incidences occur on Highways and State roads, then Primary roads, and finally Local/Subdivision/Private Roads.
- **Percent of Commercial Vehicles** measures the amount of commercial traffic on the three road designations. According to the Washtenaw Area Transportation Study Model, reported in terms of percent of total vehicle miles traveled by commercial vehicles on Washtenaw County Roads.
- **Damages** associated as itemized under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- **Expected Annual Damage** is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Hazardous Materials Fixed Site Incidents

Part A: Total Expected Annual Damage						
Expected number of incidents per year	Severity Factor - Release of Substances		Where is the impact?		Cost (Part B)	Expected Annual Damage
			Area	Amt of County Land Impacted		
5.1	Minimal damage, release	90%	Rural area	30%	\$567,775	\$781,826
		90%	Urban area	70%	\$572,645	\$1,839,908
	Moderate damage, release	7%	Rural area	30%	\$567,775	\$60,809
		7%	Urban area	70%	\$572,645	\$143,104
	Major damage, release	3%	Rural area	30%	\$567,775	\$26,061
		3%	Urban area	70%	\$572,645	\$61,330
Total expected annual damage of this hazard:						\$2,913,038

Part B: Breakdown of Costs	
Rural Area	\$567,775
Activation of EM (response, environmental clean-up)	\$50,000
Major injury (exposure)	\$15,600
Business Closure	\$500,000
Loss of Economic Activity, 1 day: 25 employees @ \$87/day	\$2,175
Urban Area	\$572,645
Activation of EM (response, environmental clean-up)	\$50,000
Major injury (1 exposure)	\$15,600
Business Closure	\$500,000
Loss of Economic Activity, 1 day:	\$2,175
Evacuations: 10 homes, 400/day	\$4,000
Evacuation of building, loss of productivity -\$87/10 employees	\$870

Explanation of Factors (by column)

- Frequency is determined from Washtenaw County Emergency Management (WCEM) 1992-2002 data.
- Severity factors are based on past incidences, WCEM data.
- Amount of County Land Impacted Percent considers the area surrounding the site. Most Hazardous Materials Sites are located in urban areas (70%).
- Damages associated as itemized under Part B. The values are taken from Table 1 of this Appendix. Damages are general estimates, not meant to be exhaustive.
- Expected Annual Damage is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Severe Winter Weather Hazard (Snow/Ice-Sleet Storms)

Part A: Total Expected Annual Damage				
Expected number of incidents per year	Area	Amt of County Land Impacted	Cost (Part B)	Expected Annual Damage by Land Type
1.9	Entire County	100%	\$19,048,297	\$36,191,763
Total expected annual damage of this hazard:				\$36,191,763

Part B: Breakdown of Costs	
Costs to County - all areas	\$19,048,297
Activation of Emergency Management	\$50,000
Response (plowing, trees)	\$50,000
Infrastructure Failure (from Infrastructure worksheet)	\$6,139,214
Impacted homes (.25% of total units, 131,069, \$5,000 per unit)	\$1,638,363
Minor Injuries (12)	\$18,720
Major Injuries (20)	\$312,000
Deaths (2: car accident; 1: exposure; 1 physical exertion)	\$10,840,000

Explanation of Factors (by column)

- Probability is determined from Washtenaw County Emergency Management 1992-2002 data.
- Amount of County land is taken as the entire County as it is not likely that one small area of the County will be impacted while the remaining land area is not. Snow, sleet or ice storms generally impact all County lands equally.
- Damages associated with events are shown under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- Expected Annual Damage is calculated by multiplying the above factors, and summing the products. This is the vulnerability determination unit.

Appendix A – Vulnerability Determination

Infrastructure

Part A: Total Expected Annual Damage				
What is the probability of an infrastructure failure occurring each year?	Area	Amt of County Land Impacted	Cost (Part B)	Expected Annual Damage by Land Type
9%	Entire County	100%	\$67,531,354	\$6,139,214
Total expected annual damage of this hazard:				\$6,139,214

Part B: Breakdown of Costs	
Costs to County - all areas	\$67,531,354
Activation of Emergency Management	\$50,000
Emergency Protective Measures (i.e. additional staffing)	\$1,700,000
Power Restoration	\$5,000,000
Economic Activity Loss for Governments	\$4,100,000
Loss of function economic, one day (10% of 242,770 employed, \$87/day)	\$2,112,099
Loss of potable water (322,895 people @ \$68/person)	\$21,956,860
Loss of power for one day (322,895 people at \$101 per day)	\$32,612,395
Death (1)	\$2,710,000

Explanation of Factors (by column)

- Probability is determined from Washtenaw County Emergency Management 1992-2002 data.
- Amount of County land is taken as the entire County as it is not likely that one small area of the County will be impacted while the remaining land area is not. Thunderstorms generally impact all County lands equally.
- Damages associated with events in different land uses are shown under Part B. The values are taken from Table 1 of this Appendix. Costs are general estimates, not meant to be exhaustive.
- Expected Annual Damage is calculated by multiplying the above factors, and summing the products. This is the vulnerability