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A Users Manual

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UNCONTROLLED HAZARDOUS WASTE SITE RANKING SYSTEM - A USERS MANUAL

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DIRECTIVE DIRECTIVE

Uncontrolled Hazardous Waste Site Ranking System

A Users Manual
(HW-10)

Originally Published in
the July 16, 1982, *Federal Register*

United States
Environmental Protection
Agency

1984

FOREWORD

The method for ranking hazardous substance facilities that is described in this document was developed by The MITRE Corporation under contract to the U.S. Environmental Protection Agency. The method has benefited from extensive review and comment by EPA personnel, state officials, and interested parties in the private sector.

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1.0 INTRODUCTION

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (PL 96-510) requires the President to identify the 400 facilities in the nation warranting the highest priority for remedial action. In order to set the priorities, CERCLA requires that criteria be established based on relative risk or danger, taking into account the population at risk; the hazardous potential of the substances at a facility; the potential for contamination of drinking water supplies, for direct human contact, and for destruction of sensitive ecosystems; and other appropriate factors.

This document describes the Hazard Ranking System (HRS) to be used in evaluating the relative potential of uncontrolled hazardous substance facilities to cause human health or safety problems, or ecological or environmental damage. Detailed instructions for using the HRS are given in the following sections. Uniform application of the ranking system in each State will permit EPA to identify those releases of hazardous substances that pose the greatest hazard to humans or the environment. However, the HRS by itself cannot establish priorities for the allocation of funds for remedial action. The HRS is a means for applying uniform technical judgement regarding the potential hazards presented by a facility relative to other facilities. It does not address the feasibility, desirability, or degree of cleanup required. Neither does it deal

with the readiness or ability of a State to carry out such remedial action as may be indicated, or to meet other conditions prescribed in CERCLA.

The HRS assigns three scores to a hazardous facility:

- S_M reflects the potential for harm to humans or the environment from migration of a hazardous substance away from the facility by routes involving ground water, surface water, or air. It is a composite of separate scores for each of the three routes.
- S_{FE} reflects the potential for harm from substances that can explode or cause fires.
- S_{DC} reflects the potential for harm from direct contact with hazardous substances at the facility (i.e., no migration need be involved).

The score for each hazard mode (migration, fire and explosion and direct contact) or route is obtained by considering a set of factors that characterize the potential of the facility to cause harm (Table 1). Each factor is assigned a numerical value (on a scale of 0 to 3, 5 or 8) according to prescribed guidelines. This value is then multiplied by a weighting factor yielding the factor score. The factor scores are then combined: scores within a factor category are added; then the total scores for each factor category are multiplied together to develop a score for ground water, surface water, air, fire and explosion, and direct contact.

In computing S_{FE} or S_{DC}, or an individual migration route score, the product of its factor category scores is divided by the maximum possible score, and the resulting ratio is multiplied by 100. The last step puts all scores on a scale of 0 to 100.

TABLE 1

COMPREHENSIVE LIST TO RATING FACTORS

HAZARD MODE	FACTOR CATEGORY	FACTORS		
		GROUND WATER ROUTE	SURFACE WATER ROUTE	AIR ROUTE
Migration	Route Characteristics	• Depth to Aquifer of Concern • Net Precipitation • Permeability of Unsaturated Zone • Physical State	• Facility Slope and Intervening Terrain • One-Year 24-Hour Rainfall • Distance to Nearest Surface Water • Physical State	
	Containment	• Containment	Containment	
	Waste Characteristics	• Toxicity/Persistence • Hazardous Waste Quantity	Toxicity/Persistence Hazardous Waste Quantity	• Reactivity/Incompatibility • Toxicity • Hazardous Waste Quantity
	Targets	• Ground Water Use • Distance to Nearest Well/ Population Served	• Surface Water Use • Distance to Sensitive Environment • Population Served/Distance to Water Intake Downstream	• Land Use • Population Within 4-Mile Radius • Distance to Sensitive Environment
Fire and Explosion	Containment	• Containment		
	Waste Characteristics	• Direct Evidence • Ignitability • Reactivity • Incompatibility • Hazardous Waste Quantity		
	Targets	• Distance to Nearest Population • Distance to Nearest Building • Distance to Nearest Sensitive Environment • Land Use • Population Within 2-Mile Radius • Number of Buildings Within 2-Mile Radius		
Direct Contact	Observed Incident	• Observed Incident		
	Accessibility	• Accessibility of Hazardous Substances		
	Containment	• Containment		
	Toxicity	• Toxicity		
	Targets	• Population Within 1-Mile Radius • Distance to Critical Habitat		

S_M is a composite of the scores for [illegible] possible migration routes:

$$S_M = \frac{1}{1.73}\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$$

where: S_{gw} = ground water route score
S_{sw} = surface water route score
S_a = air route score

The effect of this means of combining the route scores is to emphasize the primary (highest scoring) route in aggregating route scores while giving some additional consideration to the secondary or tertiary routes if they score high. The factor 1/1.73 is used simply for the purpose of reducing S_M scores to a 100-point scale.

The HRS does not quantify the probability of harm from a facility or the magnitude of the harm that could result, although the factors have been selected in order to approximate both those elements of risk. It is a procedure for ranking facilities in terms of the potential threat they pose by describing:

- the manner in which the hazardous substances are contained,
- the route by which they would be released,
- the characteristics and amount of the harmful substances, and
- the likely targets.

The multiplicative combination of factor category scores is an approximation of the more rigorous approach in which one would express the hazard posed by a facility as the product of the probability of a harmful occurrence and the magnitude of the potential damage.

The ranking of facilities nationally for remedial action will be based primarily on S_M. S_{FE} and S_{DC} may be used to identify facilities requiring emergency attention.

2.0 USING THE HAZARD RANKING SYSTEM - GENERAL CONSIDERATIONS

Use of the HRS requires considerable information about the facility, its surroundings, the hazardous substances present, and the geological character of the area down to the aquifers that may be at risk. Figure 1 illustrates a format for recording general information regarding the facility being evaluated. It can also serve as a cover sheet for the work sheets used in the evaluation.

Where there are no data for a factor, it should be assigned a value of zero. However, if a factor with no data is the only factor in a category (e.g., containment), then the factor is given a score of 1. If data are lacking for more than one factor in connection with the evaluation of either S_{gw}, S_{sw}, S_a, S_{FE} or S_{DC}, that route score is set at zero.

The following sections give detailed instructions and guidance for rating a facility. Each section begins with a work sheet designed to conform to the sequence of steps required to perform the rating. Guidance for evaluating each of the factors then follows. Using the guidance provided, attempt to assign a score for each of the three possible migration routes. Bear in mind that if data are missing for more than one factor in connection with the evaluation of a route, then you must set that route score at 0 (i.e., there is no need to assign scores to factors in a route that will be set at 0).

Facility name: _____

Location: _____

EPA Region: _____

Person(s) in charge of the facility: _____

_____

_____

Name of Reviewer: _____ Date: _____

General description of the facility:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

_____

_____

_____

_____

_____

_____

_____

Scores: S_M = (S_{gw} = S_{sw} = S_a =)

S_{FE} =

S_{DC} =

FIGURE 1
HRS COVER SHEET

3.0 GROUND WATER MIGRATION ROUTE

3.1 Observed Release

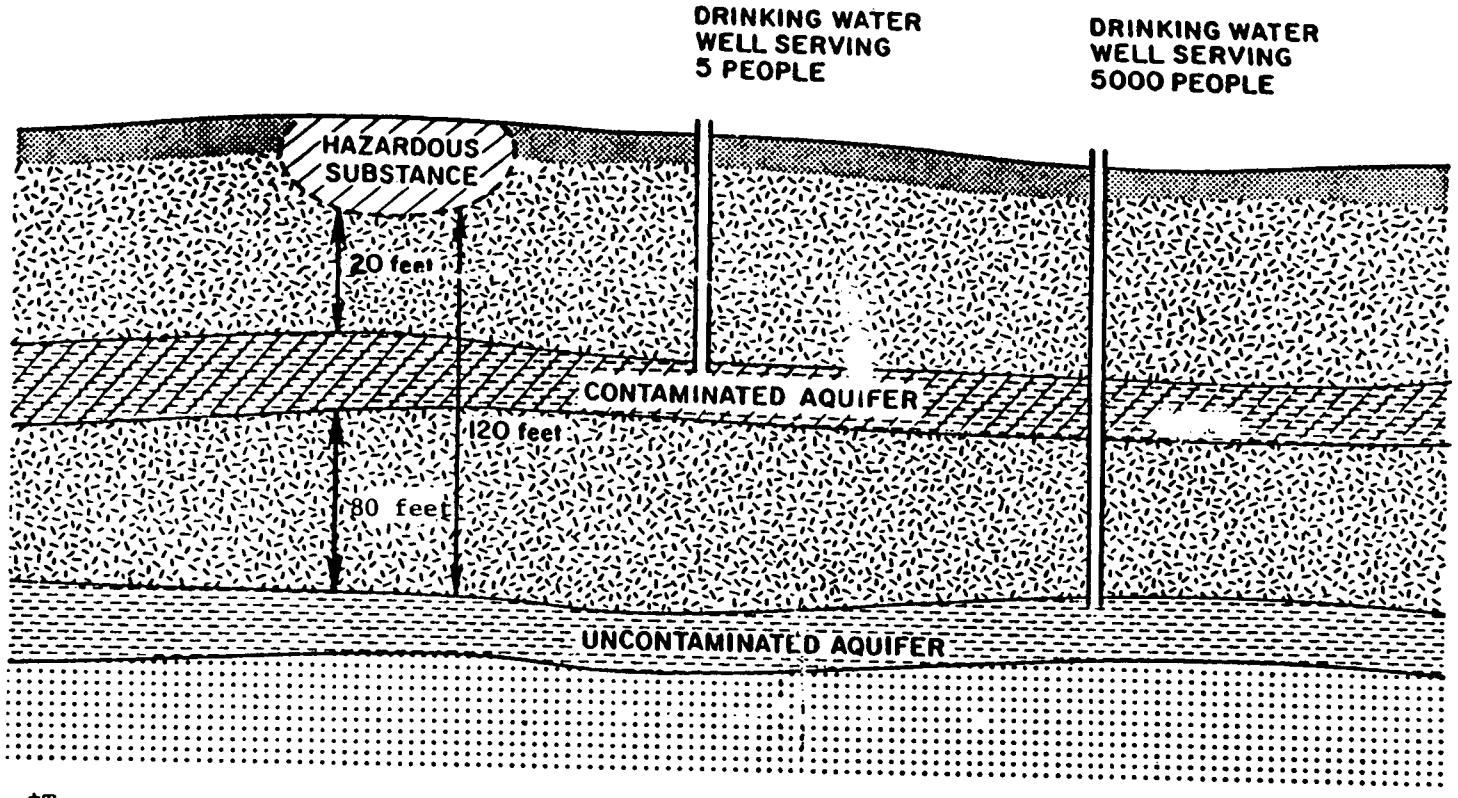
If there is direct evidence of release of a substance of concern from a facility to ground water, enter a score of 45 on line 1 of the work sheet for the ground water route (Figure 2); then you need not evaluate route characteristics and containment factors (lines 2 and 3). Direct evidence of release must be analytical. If a contaminant is measured (regardless of frequency) in ground water or in a well in the vicinity of the facility at a significantly (in terms of demonstrating that a release has occurred, not in terms of potential effects) higher level than the background level, then quantitative evidence exists, and a release has been observed. Qualitative evidence of release (e.g., an oily or otherwise objectionable taste or smell in well water) constitutes direct evidence only if it can be confirmed that it results from a release at the facility in question. If a release has been observed, proceed to "3.4 Waste Characteristics" to continue scoring. If direct evidence is lacking, enter a value of 0 on line 1 and continue the scoring procedure by evaluating Route Characteristics.

3.2 Route Characteristics

Depth to aquifer of concern is measured vertically from the lowest point of the hazardous substances to the highest seasonal level of the saturated zone of the aquifer of concern (Figure 3). This factor is one indicator of the ease with which a pollutant from the facility could migrate to ground water. Assign a value as follows:

Ground Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
[1] Observed Release	0 45	1		45	3.1
If observed release is given a score of 45, proceed to line [4]. If observed release is given a score of 0, proceed to line [2].					
[2] Route Characteristics					3.2
Depth to Aquifer of Concern	0 1 2 3	2		6	
Net Precipitation	0 1 2 3	1		3	
Permeability of the Unsaturated Zone	0 1 2 3	1		3	
Physical State	0 1 2 3	1		3	
Total Route Characteristics Score				15	
[3] Containment	0 1 2 3	1		3	3.3
[4] Waste Characteristics					3.4
Toxicity/Persistence	0 3 6 9 12 15 18	1		18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				26	
[5] Targets					3.5
Ground Water Use	0 1 2 3	3		9	
Distance to Nearest Well/Population Served	0 4 6 8 10 / 12 16 18 20 / 24 30 32 35 40	1		40	
Total Targets Score				49	
[6] If line [1] is 45, multiply [1] x [4] x [5]. If line [1] is 0, multiply [2] x [3] x [4] x [5]				57,330	
[7] Divide line [6] by 57,330 and multiply by 100	S_{gw} =				

FIGURE 2
GROUND WATER ROUTE WORK SHEET



*Treat target and route characteristics factors consistently. For example, if the upper aquifer is the aquifer of concern, then the "depth to aquifer of concern" is 20 feet and the "population served" is 5 persons. If the lower aquifer is "of concern", the "depth" is 120 feet (assuming no known contamination below the indicated "hazardous substance") and the "population" is 5000 persons. If the upper aquifer is contaminated and the lower aquifer is "of concern", the "depth" would be 80 feet (vertical distance between hazardous substance and aquifer of concern) and the population would be 5000 persons.

FIGURE 3
DEPTH TO AQUIFER OF CONCERN*

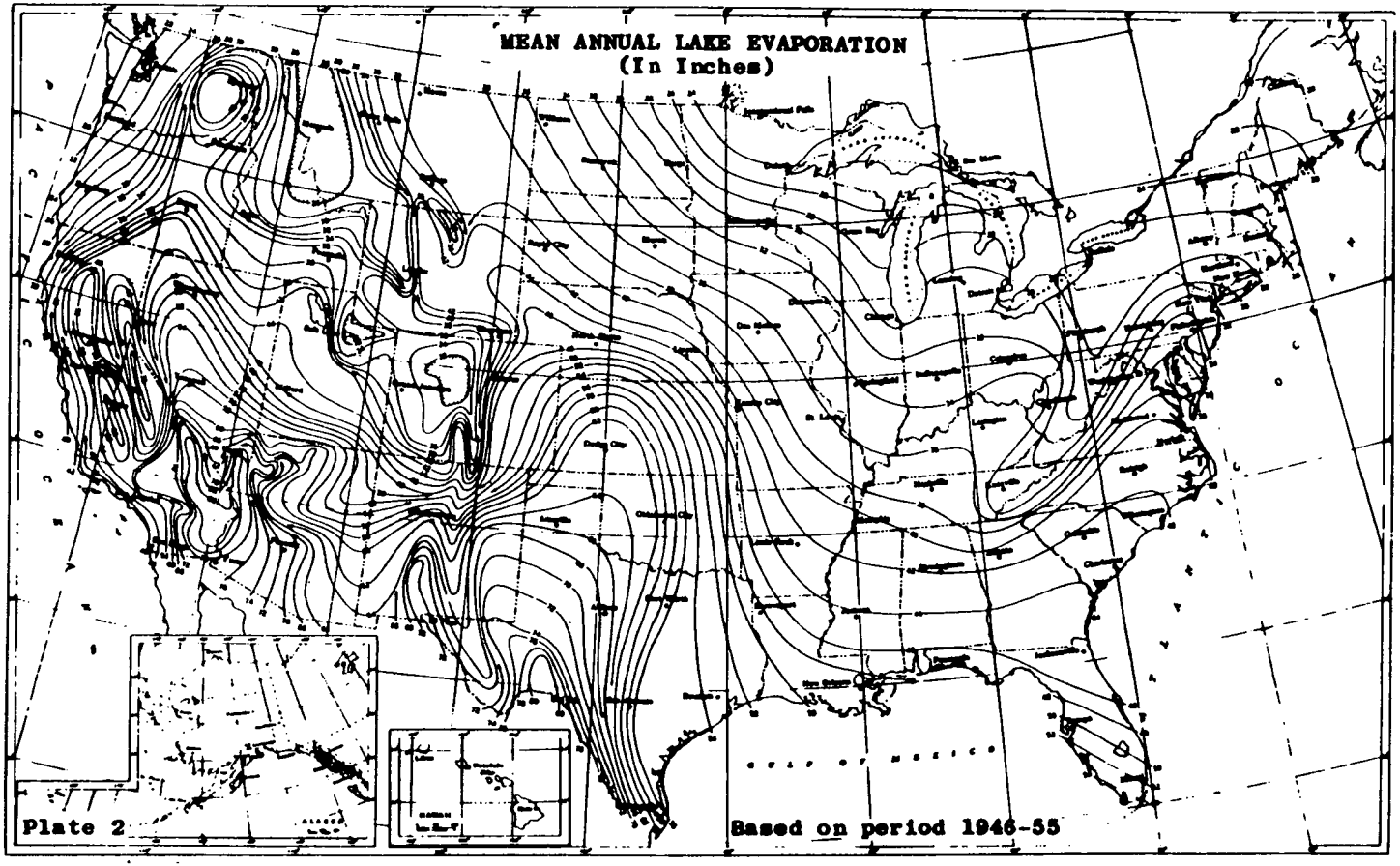
Distance	Assigned Value
>150 feet	0
76 to 150 feet	1
21 to 75 feet	2
0 to 20 feet	3

Net precipitation (precipitation minus evaporation) indicates the potential for leachate generation at the facility. Net seasonal rainfall (seasonal rainfall minus seasonal evaporation) data may be used if available. If net precipitation is not measured in the region in which the facility is located, calculate it by subtracting the mean annual lake evaporation for the region (obtained from Figure 4) from the normal annual precipitation for the region (obtained from Figure 5). EPA Regional Offices will have maps for areas outside the continental U.S. Assign a value as follows:

Net Precipitation	Assigned Value
<-10 inches	0
-10 to +5 inches	1
+5 to +15 inches	2
>+15 inches	3

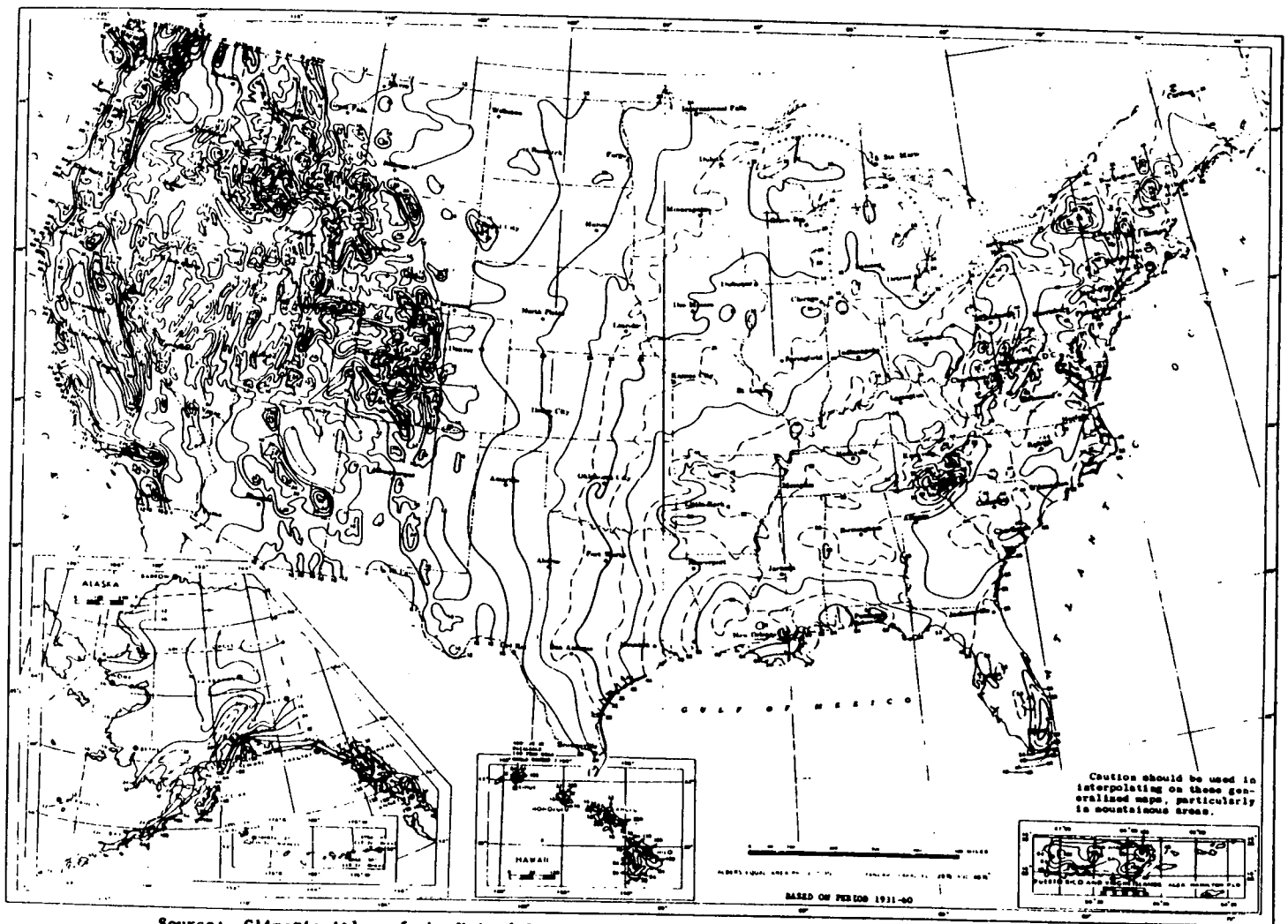
Permeability of unsaturated zone (or intervening geological formations) is an indicator of the speed at which a contaminant could migrate from a facility. Assign a value from Table 2.

Physical state refers to the state of the hazardous substances at the time of disposal, except that gases generated by the hazardous substances in a disposal area should be considered in rating this factor. Each of the hazardous substances being evaluated is assigned a value as follows:



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Ashville, N.C., 1979.

FIGURE 4
MEAN ANNUAL LAKE EVAPORATION
(IN INCHES)



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Asheville, N.C., 1979.

FIGURE 5
NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)

TABLE 2

PERMEABILITY OF GEOLOGIC MATERIALS*

Type of Material	Approximate Range of Hydraulic Conductivity	Assigned Value
Clay, compact till, shale; unfractured metamorphic and igneous rocks	$<10^{-7}$ cm/sec	0
Silt, loess, silty clays, silty loams, clay loams; less permeable limestone, dolomites, and sandstone; moderately permeable till	$10^{-5} - 10^{-7}$ cm/sec	1
Fine sand and silty sand; sandy loams; loamy sands; moderately permeable limestone, dolomites, and sandstone (no karst); moderately fractured igneous and metamorphic rocks, some coarse till	$10^{-3} - 10^{-5}$ cm/sec	2
Gravel, sand; highly fractured igneous and metamorphic rocks; permeable basalt and lavas; karst limestone and dolomite	$>10^{-3}$ cm/sec	3

*Derived from:

Davis, S. N., Porosity and Permeability of Natural Materials in Flow-Through Porous Media, R.J.M. DeWest ed., Academic Press, New York, 1969

Freeze, R.A. and J.A. Cherry, Groundwater, Prentice-Hall, Inc., New York, 1979

Physical State	Assigned Value
Solid, consolidated or stabilized	0
Solid, unconsolidated or unstabilized	1
Powder or fine material	2
Liquid, sludge or gas	3

3.3 Containment

Containment is a measure of the natural or artificial means that have been used to minimize or prevent a contaminant from entering ground water. Examples include liners, leachate collection systems, and sealed containers. In assigning a value to this rating factor (Table 3), consider all ways in which hazardous substances are stored or disposed at the facility. If the facility involves more than one method of storage or disposal, assign the highest from among all applicable values (e.g., if a landfill has a containment value of 1, and, at the same location, a surface impoundment has a value of 2, assign containment a value of 2).

3.4 Waste Characteristics

In determining a waste characteristics score, evaluate the most hazardous substances at the facility that could migrate (i.e., if scored, containment is not equal to zero) to ground water. Take the substance with the highest score as representative of the potential hazard due to waste characteristics. Note that the substance that may have been observed in the release category can differ from the

TABLE 3

CONTAINMENT VALUE FOR GROUND WATER ROUTE

Assign containment a value of 0 if: (1) all the hazardous substances at the facility are underlain by an essentially non permeable surface (natural or artificial) and adequate leachate collection systems and diversion systems are present; or (2) there is no ground water in the vicinity. The value "0" does not indicate no risk. Rather, it indicates a significantly lower relative risk when compared with more serious sites on a national level. Otherwise, evaluate the containment for each of the different means of storage or disposal at the facility using the following guidance.

A. Surface Impoundment

	Assigned Value
Sound run-on diversion structure, essentially non permeable liner (natural or artificial) compatible with the waste, and adequate leachate collection system	0
Essentially non permeable compatible liner with no leachate collection system; or inadequate freeboard	1
Potentially unsound run-on diversion structure; or moderately permeable compatible liner	2
Unsound run-on diversion structure; no liner; or incompatible liner	3

B. Containers

	Assigned Value
Containers sealed and in sound condition, adequate liner, and adequate leachate collection system	0
Containers sealed and in sound condition, no liner or moderately permeable liner	1
Containers leaking, moderately permeable liner	2
Containers leaking and no liner or incompatible liner	3

C. Piles

	Assigned Value
Piles uncovered and waste stabilized; or piles covered, waste unstabilized, and essentially non permeable liner	0
Piles uncovered, waste unstablized, moderately permeable liner, and leachate collection system	1
Piles uncovered, waste unstabilized, moderately permeable liner, and no leachate collection system	2
Piles uncovered, waste unstablized, and no liner	3

D. Landfill

	Assigned Value
Essentially non permeable liner, liner compatible with waste, and adequate leachate collection system	0
Essentially non permeable compatible liner, no leachate collection system, and landfill surface precludes ponding	1
Moderately permeable, compatible liner, and landfill surface precludes ponding	2
No liner or incompatible liner; moderately permeable compatible liner; landfill surface encourages ponding; no run-on control	3

substance used in rating waste characteristics. Where the total inventory of substances in a facility is known, only those present in amounts greater than the reportable quantity (see CERCLA Section 102 for definition) may be evaluated.

Toxicity and Persistence have been combined in the matrix below because of their important relationship. To determine the overall value for this combined factor, evaluate each factor individually as discussed below. Match the individual values assigned with the values in the matrix for the combined rating factor. Evaluate several of the most hazardous substances at the facility independently and enter only the highest score in the matrix on the work sheet.

	Value for Persistence			
Value for Toxicity	0	1	2	3
0	0	0	0	0
1	3	6	9	12
2	6	9	12	15
3	9	12	15	18

Persistence of each hazardous substance is evaluated on its biodegradability as follows:

Substance	Assigned Value
Easily biodegradable compounds	0
Straight chain hydrocarbons	1
Substituted and other ring compounds	2
Metals, polycyclic compounds and halogenated hydrocarbons	3

more specific information is given in Tables 4 and 5.

Toxicity of each hazardous substance being evaluated is given a value using the rating scheme of Sax (Table 6) or the National Fire Protection Association (NFPA) (Table 7) and the following guidance:

Toxicity	Assigned Value
Sax level 0 or NFPA level 0	0
Sax level 1 or NFPA level 1	1
Sax level 2 or NFPA level 2	2
Sax level 3 or NFPA level 3 or 4	3

Table 4 presents values for some common compounds.

Hazardous waste quantity includes all hazardous substances at a facility (as received) except that with a containment value of 0. Do not include amounts of contaminated soil or water; in such cases, the amount of contaminating hazardous substance may be estimated.

On occasion, it may be necessary to convert data to a common unit to combine them. In such cases, 1 ton = 1 cubic yard = 4 drums and for the purposes of converting bulk storage, 1 drum = 50 gallons. Assign a value as follows:

Tons/Cubic Yards	No. of Drums	Assigned Value
0	0	0
1-10	1-40	1
11-62	41-250	2
63-125	251-500	3
126-250	501-1000	4
251-625	1001-2500	5
626-1250	2501-5000	6
1251-2500	5001-10,000	7
>2500	>10,000	8

TABLE 4
WASTE CHARACTERISTICS VALUES FOR SOME COMMON CHEMICALS

CHEMICAL/COMPOUND	[1]	[2]	[3]	[4]
Acetaldehyde	3	0	3	2
Acetic Acid	3	0	2	1
Acetone	2	0	3	0
Aldrin	3	3	1	0
Ammonia, Anhydrous	3	0	1	0
Aniline	3	1	2	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	0*	0*
Chlorobenzene	2	2	3	0
Chloroform	3	3	0	0
Cresol-O	3	1	2	0
Cresol-M&P	3	1	1	0
Cyclohexane	2	2	3	0
Endrin	3	3	1	0
Ethyl Benzene	2	1	3	0
Formaldehyde	3	0	2	0
Formic Acid	3	0	2	0
Hydrochloric Acid	3	0	0	0
Isopropyl Ether	3	1	3	1
Lindane	3	3	1	0
Methane	1	1	3	0
Methyl Ethyl Ketone	2	0	3	0
Methyl Parathion in Xylene Solution	3	0Δ	3	2
Naphthalene	2	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	0Δ	1	2
PCB	3	3	0Δ	0Δ
Petroleum, Kerosene (Fuel Oil No. 1)	3	1	2	0
Phenol	3	1	2	0
Sulfuric Acid	3	0	0	2
Toluene	2	1	3	0
Trichlorobenzene	2	3	1	0
α-Trichloroethane	2	2	1	0
Xylene	2	1	3	0

[1] Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Co., New York, 4th ed., 1975. The highest rating listed under each chemical is used.

[2] JRB Associates, Inc., Methodology for Rating the Hazard Potential of Waste Disposal Sites, May 5, 1980.

[3] National Fire Protection Association, National Fire Codes, Vol. 13, No. 49, 1977.

* Professional judgment based on information contained in the U.S. Coast Guard CHRIS Hazardous Chemical Data, 1978.

Δ Professional judgment based on existing literature.

TABLE 5

PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS*

VALUE = 3 HIGHLY PERSISTENT COMPOUNDS

aldrin
benzopyrene
benzothiazole
benzothiophene
benzyl butyl phthalate
bromochlorobenzene
bromoform butanal
bromophenyl phynil ether
chlordane
chlorohydroxy benzephenone
bis-chloroisoprophyl ether
m-chloronitrobenzene
DDE
DDT
dibromobenzene
dibutyl phthalate
1, 4-dichlorobenzene
dichlorodifluoroethane
dieldrin
diethyl phthalate
di(2-ethylhexyl)phthalate
dihexyl phthalate
di-isobutyl phthalate
dimethyl phthalate
4,6-dinitro-2-aminophenol
dipropyl phthalate
endrin
heptachlor
heptachlor epoxide
1,2,3,4,5,7,7-heptachloronorbornene
hexachlorobenzene
hexachloro-1,3-butadiene
hexachlorocyclohexane
hexachloroethane
methyl benzothiazole
pentachlorobiphenyl
pentachlorophenol
1,1,3,3-tetrachloroacetone
tetrachlorobiphenyl
thiomethylbenzothiazole
trichlorobenzene
trichlorobiphenyl
trichlorofluoromethane
2,4,6-trichlorophenol
triphenyl phosphate
bromodichloromethane
bromoform
carbon tetrachloride
chloroform
chloromochloromethane
dibromodichloroethane
tetrachloroethane
1,1,2-trichloroethane

VALUE = 1 SOMEWHAT PERSISTENT COMPOUNDS

acetylene dichloride
behenic acid, methyl ester
benzene
benzene sulfonic acid
butyl benzene
butyl bromide
e-caprolactam
carbon-disulfide
o-cresol
decane
1,2-dichloroethane
1,2-dimethoxy benzene
1,3-dimethyl naphthalene
1,4-dimethyl phenol
dioctyl adipate
n-dodecane
ethyl benzene
2-ethyl-n-hexane
o-ethyltoluene
isodecane
isoprophyl benzene
limonene
methyl ester of lignoceric acid
methane
2-methyl-5-ethyl-pyridine
methyl naphthalene
methyl palaitate
methyl phenyl carbinol
methyl stearate
naphthalene
nonane
octane
octyl chloride
pentane
phenyl benzoate
phthalic anhydride
propylbenzene
l-terpineol
toluene
vinyl benzene
xylene

VALUE = 2 PERSISTENT COMPOUNDS

acenaphthylene
atrazine
(diethyl) atrazine
barbital
borneol
bromobenzene
camphor
chlorobenzene
1,2-bis-chloroethoxy ethane
b-chloroethyl methyl ether
chloromethyl ether
chloromethyl ethyl ether
3-chloropyridine
di-t-butyl-p-benzoquinone
dichloroethyl ether
dihyrocarvone
dimethyl sulfoxide
2,6-dinitrotoluene
cis-2-ethyl-4-methyl-1,3-dioxolane
trans-2-ethyl-4-methyl-1,3-dioxolane
guaiacol
2-hydroxyadiponitrile
isophorone
indene
isoborneol
isopropenyl-r-isopropyl benzene
2-methoxy biphenyl
methyl biphenyl
methyl chloride
methylindene
methylene chloride
nitroanisole
nitrobenzene
1,1,2-trichloroethylene
trimethyl-trioxo-hexahydro-triazine isomer

VALUE = 0 NONPERSISTENT COMPOUNDS

acetaldehyde
acetic acid
acetone
acetophanone
benzoic acid
di-isobutyl carbinol
docosane
eicosane
ethanol
ethylamine
hexadecane
methanol
methyl benzoate
3-methyl butanol
methyl ethyl ketone
2-methylpropanol
octadecane
pentadecane
pentanol
propanol
propylamine
tetradecane
n-tridecane
n-undecane

TABLE 6

SAX TOXICITY RATINGS

0 = No Toxicity* (None)**

This designation is given to materials which fall into one of the following categories:

(a) Materials which cause no harm under any conditions of normal use.

(b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage.

1 = Slight Toxicity* (Low)**

(a) *Acute local.* Materials which on single exposures lasting seconds, minutes, or hours cause only slight effects on the skin or mucuous membranes regardless of the extent of the exposure.

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose, regardless of the quantity absorbed or the extent of exposure.

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause only slight and usually reversible harm to the skin or mucous membranes. The extent of exposure may be great or small.

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slightly usually reversible effects extending over days, months, or years. The extent of the exposure may be great or small.

In general, those substances classified as having "slight toxicity" produce changes in the human body which are readily reversible and which will disappear following termination of exposure, either with or without medical treatment.

2 = Moderate Toxicity* (Mod)**

(a) *Acute local.* Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter or seconds or moderate exposure for a matter of hours.

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and produce moderate effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose.

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years causes moderate harm to the skin or mucous membranes.

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months, or years.

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are not of such severity as to threaten life or to produce serious physical impairment.

3 = Severe Toxicity* (High)**

(a) *Acute local.* Materials which on single exposure lasting seconds or minutes cause injury to skin or mucous membranes or sufficient severity to threaten life or to cause permanent physical impairment or disfigurement.

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes, or hours, or following ingestion of a single dose.

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or cause permanent impairment, which disfigurement, or irreversible change.

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months, or years.

*Sax, N.I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Company, New York, 4th Edition, 1975.

**Sax, N.I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Company, New York, 5th Edition, 1979.

TABLE 7

NFPA TOXICITY RATINGS*

0	Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material.
1	Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus.
2	Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
3	Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing, including self-contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed.
4	A few whiffs of the gas or vapor could cause death, or the gas, vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing which is designed for resistance to heat. For most chemicals having a Health 4 rating, the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn.

*National Fire Protection Association. National Fire Codes, Vol. 13, No. 49, 1977.

3.5 Targets

Ground water use indicates the nature of the use made of ground water drawn from the aquifer of concern within 3 miles of the hazardous substance, including the geographical extent of the measurable concentration in the aquifer. Assign a value using the following guidance:

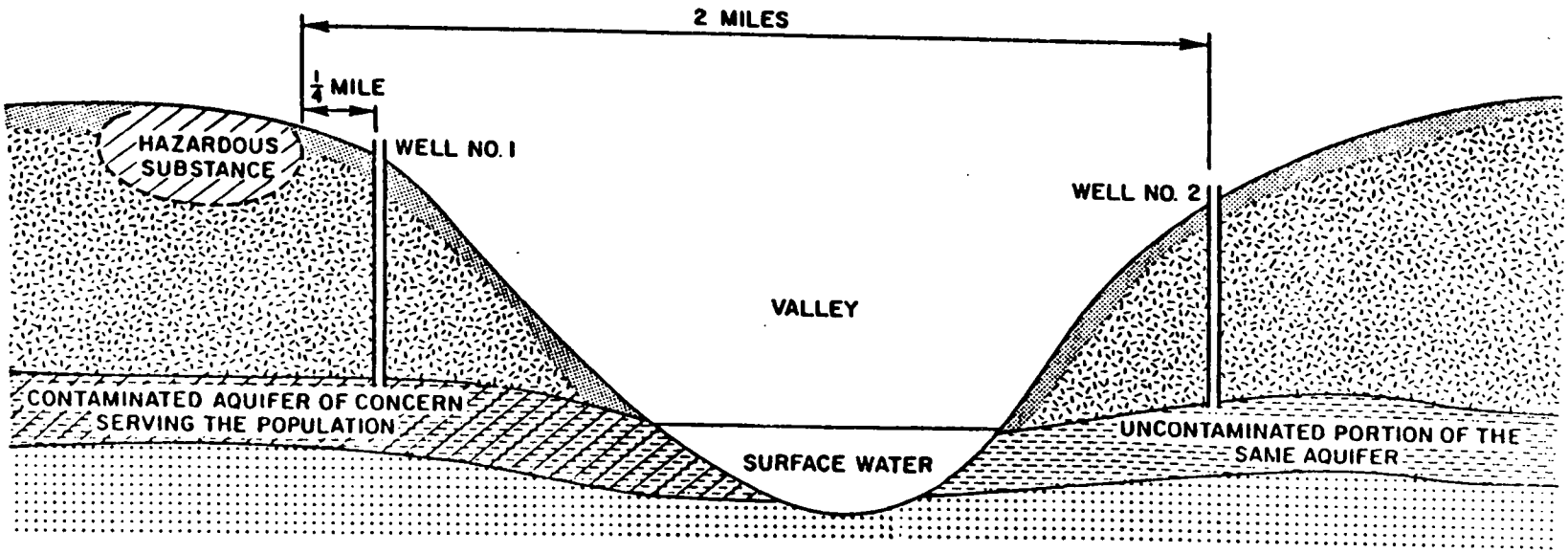
Ground Water Use	Assigned Value
Unusable (e.g., extremely saline aquifer, extremely low yield, etc.)	0
Commercial, industrial or irrigation and another water source presently available; not used, but usable	1
Drinking water with municipal water from alternate unthreatened sources presently available (i.e., minimal hookup requirements); or commercial, industrial or irrigation with no other water source presently available	2
Drinking water; no municipal water from alternate unthreatened sources presently available	3

Distance to nearest well and population served have been combined in the matrix below to better reflect the important relationship between the distance of a population from hazardous substances and the size of the population served by ground water that might be contaminated by those substances. To determine the overall value for this combined factor, score each individually as discussed below. Match the individual values assigned with the values in the matrix for the total score.

Value for Population Served	Value for Distance to Nearest Well				
	0	1	2	3	4
0	0	0	0	0	0
1	0	4	6	8	10
2	0	8	12	16	20
3	0	12	18	24	30
4	0	16	24	32	35
5	0	20	30	35	40

Distance to nearest well is measured from the hazardous substance (not the facility boundary) to the nearest well that draws water from the aquifer of concern. If the actual distance to the nearest well is unknown, use the distance between the hazardous substance and the nearest occupied building not served by a public water supply (e.g., a farmhouse). If a discontinuity in the aquifer occurs between the hazardous substance and all wells, give this factor a score of 0, except where it can be shown that the contaminant is likely to migrate beyond the discontinuity. Figure 6 illustrates how the distance should be measured. Assign a value using the following guidance:

Distance	Assigned Value
>3 miles	0
2 to 3 miles	1
1 to 2 miles	2
2001 feet to 1 mile	3
< 2000 feet	4



In the situation depicted above, the distance between the hazardous substance and the nearest well (No. 1) is ¼ mile. If well No. 1 did not exist, the distance to well No. 2 would be immaterial since there is a discontinuity in the aquifer (surface water) between it and the hazardous substance. Under such circumstances, the factor score would be "0". However, if it could be demonstrated that the contaminent had bridged the discontinuity, then the distance to the nearest well would be 2 miles (assuming well No. 1 does not exist).

FIGURE 6
DISTANCE TO NEAREST WELL

Population served by ground water is an indicator of the population at risk, which includes residents as well as others who would regularly use the water such as workers in factories or offices and students. Include employees in restaurants, motels, or campgrounds but exclude customers and travelers passing through the area in autos, buses, or trains. If aerial photography is used, and residents are known to use ground water, assume each dwelling unit has 3.8 residents. Where ground water is used for irrigation, convert to population by assuming 1.5 persons per acre of irrigated land. The well or wells of concern must be within three miles of the hazardous substances, including the area of known aquifer contamination, but the "population served" need not be. Likewise, people within three miles who do not use water from the aquifer of concern are not to be counted. Assign a value as follows:

Population	Assigned Value
0	0
1-100	1
101-1,000	2
1,001-3,000	3
3,001-10,000	4
>10,000	5

4.0 SURFACE WATER ROUTE

4.1 Observed Release

Direct evidence of release to surface water must be quantitative evidence that the facility is releasing contaminants into surface water. Quantitative evidence could be the measurement of levels of contaminants from a facility in surface water, either at the facility or downhill from it, that represents a significant (in terms of demonstrating that a release has occurred, not in terms of potential effects) increase over background levels. If direct evidence of release has been obtained (regardless of frequency), enter a value of 45 on line 1 of the work sheet (Figure 7) and omit the evaluation of the route characteristics and containment factors. If direct evidence of release is lacking, enter a value of 0 on line 1 and continue with the scoring procedure.

4.2. Route Characteristics

Facility slope and intervening terrain are indicators of the potential for contaminated runoff or spills at a facility to be transported to surface water. The facility slope is an indicator of the potential for runoff or spills to leave the facility. Intervening terrain refers to the average slope of the shortest path which would be followed by runoff between the facility boundary and the nearest downhill surface water. This rating factor can be assessed using topographic maps. Table 8 shows values assigned to various facility conditions.

Surface Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	R (Section)
1 Observed Release	0 45	1		45	4.1
If observed release is given a value of 45, proceed to line 4. If observed release is given a value of 0, proceed to line 2.					
2 Route Characteristics					4.2
Facility Slope and Intervening Terrain	0 1 2 3			3	
1-yr. 24-hr. Rainfall	0 1 2 3	1		3	
Distance to Nearest Surface Water	0 1 2 3	2		6	
Physical State	0 1 2 3	1		3	
Total Route Characteristics Score				15	
3 Containment	0 1 2 3	1		3	4.3
4 Waste Characteristics					4.4
Toxicity/Persistence	0 3 6 9 12 15 18	1		18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				26	
5 Targets					4.5
Surface Water Use	0 1 2 3	3		9	
Distance to a Sensitive Environment	0 1 2 3	2		6	
Population Served/Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	1		40	
Total Targets Score				55	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				64,350	
7 Divide line 6 by 64,350 and multiply by 100		S_{SW} =			

FIGURE 7
SURFACE WATER ROUTE WORK SHEET

TABLE 8

VALUES FOR FACILITY SLOPE AND INTERVENING TERRAIN

Facility Slope	Intervening Terrain				
	Terrain Average Slope ≤3%; or Site Separated from Water Body by Areas of Higher Elevation	Terrain Average Slope 3-5%	Terrain Average Slope 5-8%	Terrain Average Slope >8%	Site in Surface Water
Facility is closed basin	0	0	0	0	3
Facility has average slope ≤3%	0	1	1	2	3
Average slope 3-5%	0	1	2	2	3
Average slope 5-8%	0	2	2	3	3
Average slope >8%	0	2	3	3	3

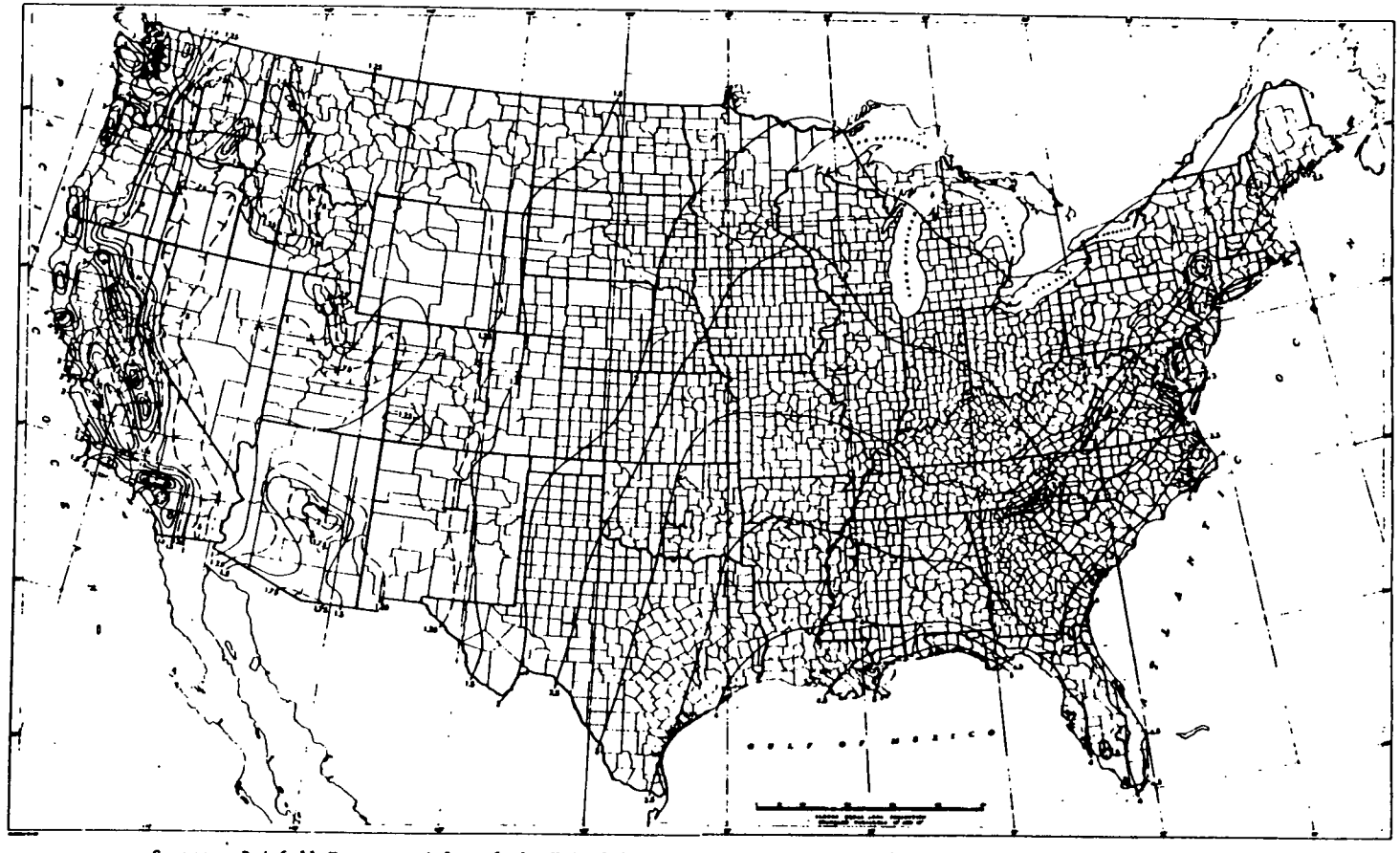
One-year 24-hour rainfall (obtained from Figure 8) indicates the potential for area storms to cause surface water contamination as a result of runoff, erosion, or flow over dikes. Assign a value as follows:

Amount of Rainfall (inches)	Assigned Value
<1.0	0
1.0-2.0	1
2.1-3.0	2
>3.0	3

Distance to the nearest surface water is the shortest distance from the hazardous substance, (not the facility or property boundary) to the nearest downhill body of surface water (e.g., lake or stream) that is on the course that runoff can be expected to follow and that at least occasionally contains water. Do not include man-made ditches which do not connect with other surface water bodies. In areas having less than 20 inches of normal annual precipitation (see Figure 5), consider intermittent streams. This factor indicates the potential for pollutants flowing overland and into surface water bodies. Assign a value as follows:

Distance	Assigned Value
>2 miles	0
1 to 2 miles	1
1000 feet to 1 mile	2
<1000 feet	3

Physical state is assigned a value using the procedures in Section 3.2.



Source: Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1963.

FIGURE 8
1-YEAR 24-HOUR RAINFALL
(INCHES)

4.3 Containment

Containment is a measure of the means that have been taken to minimize the likelihood of a contaminant entering surface water either at the facility or beyond the facility boundary. Examples of containment are diversion structures and the use of sealed containers. If more than one type of containment is used at a facility, evaluate each separately (Table 9) and assign the highest score.

4.4 Waste Characteristics

Evaluate waste characteristics for the surface water route with the procedures described in Section 3.4 for the ground water route.

4.5 Targets

Surface water use brings into the rating process the use being made of surface water downstream from the facility. The use or uses of interest are those associated with water taken from surface waters within a distance of three miles from the location of the hazardous substance. Assign a value as follows:

Surface Water Use (Fresh or Salt Water)	Assigned Value
Not currently used	0
Commercial or industrial	1
Irrigation, economically important resources (e.g., shellfish), commercial food preparation, or recreation (e.g., fishing, boating, swimming)	2
Drinking Water	3

TABLE 9

CONTAINMENT VALUES FOR SURFACE WATER ROUTE

Assign containment a value of 0 if: (1) all the waste at the site is surrounded by diversion structures that are in sound condition and adequate to contain all runoff, spills, or leaks from the waste; or (2) intervening terrain precludes runoff from entering surface water. Otherwise, evaluate the containment for each of the different means of storage or disposal at the site and assign a value as follows:

A. Surface Impoundment

	Assigned Value
Sound diking or diversion structure, adequate freeboard, and no erosion evident	0
Sound diking or diversion structure, but inadequate freeboard	1
Diking not leaking, but potentially unsound	2
Diking unsound, leaking, or in danger of collapse	3

B. Containers

	Assigned Value
Containers sealed, in sound condition, and surrounded by sound diversion or containment system	0
Containers sealed and in sound condition, but not surrounded by sound diversion or containment system	1
Containers leaking and diversion or containment structures potentially unsound	2
Containers leaking, and no diversion or containment structures or diversion structures leaking or in danger of collapse	3

C. Waste Piles

	Assigned Value
Piles are covered and surrounded by sound diversion or containment system	0
Piles covered, wastes unconsolidated, diversion or containment system not adequate	1
Piles not covered, wastes unconsolidated, and diversion or containment system potentially unsound	2
Piles not covered, wastes unconsolidated, and no diversion or containment or diversion system leaking or in danger or collapse	3

D. Landfill

	Assigned Value
Landfill slope precludes runoff, landfill surrounded by sound diversion system, or landfill has adequate cover material	0
Landfill not adequately covered and diversion system sound	1
Landfill not covered and diversion system potentially unsound	2
Landfill not covered and no diversion system present, or diversion system unsound	3

Distance to a sensitive environment refers to the distance from the hazardous substance (not the facility boundary) to an area containing an important biological resource or to a fragile natural setting that could suffer an especially severe impact from pollution. Table 10 provides guidance on assigning a value to this rating factor.

Population served by surface water with water intake within 3 miles downstream from facility (or 1 mile in static surface water such as a lake) is a rough indicator of the potential hazard exposure of the nearby population served by potentially contaminated surface water. Measure the distance from the probable point of entry to surface water following the surface water flow (stream miles). The population includes residents as well as others who would regularly use the water such as workers in factories or offices and students. Include employees in restaurants, motels, or campgrounds but exclude customers and travelers passing through the area in autos, buses and trains. The distance is measured from the hazardous substance, including observations in stream or sediment samples, regardless of facility boundaries. Where only residential houses can be counted (e.g., from an aerial photograph), and residents are known to be using surface water, assume 3.8 individuals per dwelling unit. Where surface water is used for irrigation, convert to population by assuming 1.5 persons per acre of land irrigated. Assign a value as follows:

TABLE 10

VALUES FOR SENSITIVE ENVIRONMENT (SURFACE WATER)

ASSIGNED VALUE =	0	1	2	3
DISTANCE TO WETLANDS* (5 acre minimum)				
Coastal	>2 miles	1 - 2 miles	½ - 1 mile	< ½ mile
Fresh Water	>1 mile	¼ - 1 mile	100 feet - ¼ mile	< 100 feet
DISTANCE TO CRITICAL HABITAT (of endangered species)**	>1 mile	½ - 1 mile	¼ - ½ mile	< ¼ mile

*Wetland is defined by EPA in the Code of Federal Regulations 40 CFR Part 230, Appendix A, 1980

**Endangered species are designated by the U.S. Fish and Wildlife Service.

Distance to Surface Water

Population	>3 miles	2-3 miles	1-2 miles	2001 feet to 1 mile	0-2000 feet
0	0	0	0	0	0
1-100	0	4	6	8	10
101-1000	0	8	12	16	20
1001-3000	0	12	18	24	30
3001-10,000	0	16	24	32	35
>10,000	0	20	30	35	40

5.0 AIR ROUTE

5.1 Observed Release

The only acceptable evidence of release for the air route is data that show levels of a contaminant at or in the vicinity of the facility that significantly exceed background levels, regardless of the frequency of occurrence. If such evidence exists, enter a value of 45 on line 1 of the work sheet (Figure 9); if not, assign line 1 a 0 value and then $S_a = 0$. Record the date, location, and the sampling protocol for monitoring data on the work sheet. Data based on transitory conditions due to facility disturbance by investigative personnel are not acceptable.

5.2 Waste Characteristics

The hazardous substance that was observed for scoring the release category may be different from the substance used to score waste characteristics.

Reactivity and incompatibility, measures of the potential for sudden releases of concentrated air pollutants, are evaluated independently, and the highest value for either is recorded on the work sheet.

Reactivity provides a measure of the fire/explosion threat at a facility. Assign a value based on the reactivity classification used by NFPA (see Table 11). Reactivity ratings for a number of common compounds are given in Table 4.

Air Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
[1] Observed Release	0 45	1		45	5.1
Date and Location:					
Sampling Protocol:					
If line [1] is 0, then S_a = 0. Enter on line [5]. If line [1] is 45, then proceed to line [2].					
[2] Waste Characteristics					5.2
Reactivity and Incompatibility	0 1 2 3	1		3	
Toxicity	0 1 2 3	3		9	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			20	
[3] Targets					5.3
Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	1		30	
Distance to Sensitive Environment	0 1 2 3	2		6	
Land Use	0 1 2 3	1		3	
	Total Targets Score			39	
[4] Multiply [1] x [2] x [3]				35,100	
[5] Divide line [4] by 35,100 and multiply by 100		S_a =			

FIGURE 9
AIR ROUTE WORK SHEET

TABLE 11

	NFPA [illegible]	Assigned value
0	Materials which are normally stable even under fire exposure conditions and which are not reactive with water.	0
1	Materials which in themselves are normally stable but which may become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.	1
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Includes materials which can undergo chemical change with rapid release of energy at normal temperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. Also includes those materials which may react violently with water or which may form potentially explosive mixtures with water.	2
3	Materials which in themselves are capable of detonation or of explosive decomposition or of explosive reaction but which requires a strong initiating source or which must be heated under confinement before initiation. Includes materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement.	3
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at noraml temperatures and pressures. Includes materials which are sensitive to mechanical or localized thermal shock.	3

Incompatibility provides a measure of the increased hazard when hazardous substances are mixed under uncontrolled conditions, leading to production of heat, pressure, fire, explosion, violent reaction, toxic dusts, mists, fumes or gases, or flammable fumes or gases. Table 12 provides examples of incompatible combinations of materials. Additional information can be obtained from A Method for Determining the Compatibility of Hazardous Wastes, H. K. Hatayama, et al., EPA-600/2-80-076 (1980). Assign a value using the following guidance:

Incompatibility	Assigned Value
No incompatible substances are present	0
Present but do not pose a hazard	1
Present and may pose a future hazard	2
Present and posing an immediate hazard	3

Toxicity should be rated for the most toxic of the substances that can reasonably be expected to be transported away from the facility via the air route. Using the information given in Tables 4, 6, and 7, assign values as follows:

Toxicity	Assigned Value
Sax level 0 or NFPA level 0	0
Sax level 1 or NFPA level 1	1
Sax level 2 or NFPA level 2	2
Sax level 3 or NFPA levels 3 or 4	3

TABLE 12

INCOMPATIBLE MATERIALS

In the lists below, the mixing of a Group A material with a Group B material may have the potential consequence as noted.

Group 1-A	Group 1-B
Acetylene sludge	Acid sludge
Akaline caustic liquids	Acid and water
Alkaline cleaner	Battery acid
Alkaline corrosive liquids	Chemical cleaners
Alkaline corrosive battery fluid	Electrolyte acid
Caustic wastewater	Etching acid liquid or solvent
Lime sludge and other corrosive alkalies	Pickling liquor and other corrosive acids
Lime wastewater	Spent acid
Lime and water	Spent mixed acid
Spent caustic	Spent sulfuric acid

Potential consequences: Heat generation; violent reaction.

Group 2-A	Group 2-B
Aluminum	Any waste in Group 1-A or 1-B
Beryllium	
Calcium	
Lithium	
Potassium	
Sodium	
Zinc powder	
Other reactive metals and metal hydrides	

Potential consequences: Fire or explosion; generation of flammable hydrogen gas.

Group 3-A	Group 3-B
Alcohols	Any concentrated waste in Groups 1-A or 1-B
Water	Calcium
	Lithium
	Metal hydrides
	Potassium
	SO_2Cl_2, $SOCl_2$, PCl_2, CH_3, $SiCl_3$
	Other water-reactive waste

Potential consequences: Fire, explosion, or heat generation; generation of flammable or toxic gases.

Group 4-A	Group 4-B
Alcohols	Concentrated Group 1-A or 1-B wastes
Aldehydes	Group 2-A wastes
Halogenated hydrocarbons	
Nitrated hydrocarbons	
Unsaturated hydrocarbons	
Other reactive organic compounds and solvents	

Potential consequences: Fire, explosion, or violent reaction.

Group 5-A	Group 5-B
Spent cyanide and sulfide solutions	Group 1-B wastes

Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.

Group 6-A	Group 6-B
Chlorates	Acetic acid and other organic acids
Chlorine	Concentrated mineral acides
Chlorites	Group 2-A wastes
Chromic acid	Group 4-A wastes
Hyphochlorites	Other flammable and combustible wastes
Nitrates	
Nitric acid, fuming	
Perchlorates	
Permanganates	
Peroxides	
Other strong oxidizers	

Potential consequences: Fire, explosion, or violent reaction.

Source: Hazardous Waste Management Law, Regulations, and Guidelines for the Handling of Hazardous Waste. California Department of Health, Sacramento, California, February 1975.

Hazardous Waste Quantity

Assign hazardous waste quantity a value as described in Section 3.4.

5.3 Targets

Population within a four-mile radius is an indicator of the population which may be harmed should hazardous substances be released to the air.

The distance is measured from the location of the hazardous substances, not from the facility boundary. The population to be counted includes persons residing within the four-mile radius as well as transients such as workers in factories, offices, restaurants, motels, or students. It excludes travelers passing through the area. If aerial photography is used in making the count, assume 3.8 individuals per dwelling unit. Select the highest value for this rating factor as follows:

	Distance to Population from Hazardous Substance			
Population	0-4 miles	0-1 mile	0-1/2 mile	0-1/4 mile
0	0	0	0	0
1-100	9	12	15	18
101-1000	12	15	18	21
1001-3000	15	18	21	24
3001-10,000	18	21	24	27
>10,000	21	24	27	30

Distance to sensitive environment is an indicator of the likelihood that a region that contains important biological resources or that is a fragile natural setting would suffer serious

damage if hazardous substances were to be released from the facility. Assign a value from Table 10.

Land use indicates the nature and level of human activity in the vicinity of a facility. Assign highest applicable value from Table 13.

TABLE 13

VALUES FOR LAND USE (AIR ROUTE)

ASSIGNED VALUE =	0	1	2	3
Distance to Commercial-Industrial	>1 mile	½ - 1 mile	¼ - ½ mile	< ¼ mile
Distance to National/State Parks, Forests, Wildlife Reserves, and Residential Areas	>2 miles	1 - 2 miles	¼ - 1 mile	< ¼ mile
Distance to Agricultural Lands (in Production within 5 years)				
Ag Land	>1 mile	½ - 1 mile	¼ - ½ mile	< ¼ mile
Prime Ag Land*	>2 miles	1 - 2 miles	½ - 1 mile	< ½ mile
Distance to Historic/Landmark Sites (National Register of Historic Places and National Natural Landmarks)				within view of site or if site is subject to significant impacts

*Defined in the Code of Federal Regulations, 7 CFR 657.5, 1981.

6.0 COMPUTING THE MIGRATION HAZARD MODE SCORE, S_M

To compute S_M, complete the work sheet (Figure 10) using the values of S_{gw}, S_{sw} and S_a obtained from the previous sections.

	S	S^2
Groundwater Route Score (S_{gw})		
Surface Water Route Score (S_{sw})		
Air Route Score (S_a)		
$S_{gw}^2 + S_{sw}^2 + S_a^2$		
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$		
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} \,/\, 1.73 = S_M =$		

FIGURE 10
WORKSHEET FOR COMPUTING S_M

7.0 FIRE AND EXPLOSION

Compute a score for the fire and explosion hazard mode, S_{FE}, when either a state or local fire marshall has certified that the facility presents a significant fire or explosion threat to the public or to sensitive environments or there is a demonstrated fire and explosion threat based on field observations (e.g., combustible gas indicator readings). Document the threat.

7.1 Containment

Containment is an indicator of the measures that have been taken to minimize or prevent hazardous substances at the facility from catching fire or exploding. Normally it will be given a value of 3 on the work sheet (Figure 11). If no hazardous substances that are individually ignitable or explosive are present and those that may be hazardous in combination are segregated and isolated so that they cannot come together to form incompatible mixtures, assign this factor a value of 1.

7.2 Waste Characteristics

Direct evidence of ignitability or explosion potential may exist in the form of measurements with appropriate instruments. If so, assign this factor a value of 3; if not, assign a value of 0.

Ignitability is an indicator of the threat of fire at a facility and the accompanying potential for release of air contaminants. Assign this rating factor a value based on the NFPA classification scheme (Table 14). Table 4 gives values for a number of common compounds. Assign values as follows:

Fire and Explosion Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Containment	1 3	1		3	7.1
2 Waste Characteristics					7.2
Direct Evidence	0 3	1		3	
Ignitability	0 1 2 3	1		3	
Reactivity	0 1 2 3	1		3	
Incompatibility	0 1 2 3	1		3	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				20	
3 Targets					7.3
Distance to Nearest Population	0 1 2 3 4 5	1		5	
Distance to Nearest Building	0 1 2 3	1		3	
Distance to Sensitive Environment	0 1 2 3	1		3	
Land Use	0 1 2 3	1		3	
Population Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Buildings Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Total Targets Score				24	
4 Multiply 1 x 2 x 3				1,440	
5 Divide line 4 by 1,440 and multiply by 100		S_{FE} =			

FIGURE 11
FIRE AND EXPLOSION WORK SHEET

TABLE 14

NFPA IGNITABILITY LEVELS AND ASSIGNED VALUES

NFPA LEVEL	ASSIGNED VALUE
4 Very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air. 3 Liquids which can be ignited under all normal temperature conditions. Any material that ignites spontaneously at normal temperatures in air.	3
2 Liquids which must be moderately heated before ignition will occur and solids that readily give off flammable vapors.	2
1 Materials that must be preheated before ignition can occur. Most combustible solids have a flammability rating of 1.	1
0 Materials that will not burn.	0

Ignitability	Assigned Value
Flashpoint 200°F, or NFPA level 0	0
Flashpoint 140°F to 200°F or NFPA level 1	1
Flashpoint 80°F to 140°F or NFPA level 2	2
Flashpoint 80°F or NFPA levels 3 or 4	3

Reactivity. Assign values as in Section 5.2.

Incompatibility. Assign values as in Section 5.2.

Hazardous Waste Quantity. Assign values as in Section 3.4.

7.3 Targets

Distance to nearest population is the distance from the hazardous substance to the nearest building or area in which one or more persons are likely to be located either for residential, educational, business, occupational, or recreational purposes. It is an indicator of the potential for harm to humans from fire and explosion. The building or area need not be off-site. Assign values as follows:

Distance	Assigned Value
>2 miles	0
1 mile - 2 miles	1
1/2 mile - 1 mile	2
201 feet - 1/2 mile	3
51 feet - 200 feet	4
0 - 50 feet	5

Distance to nearest building is an indicator of the potential for property damage as a result of fire or explosion. Assign a value as follows:

Distance	Assigned Value
>1/2 mile	0
201 feet - 1/2 mile	1
51 - 200 feet	2
0 - 50 feet	3

Distance to nearest sensitive environment is measured from the hazardous substances, not from the facility boundary. It is an indicator of potential harm to a sensitive environment from fire or explosion at the facility. Select the highest value using the guidance provided in Table 15 except assign a value of 3 where fire could be expected to spread to a sensitive environment even though that environment is more than 100 feet from the hazardous substance.

Land Use. Assign values as in Section 5.3.

Population within two-mile radius (measured from the location of the hazardous substance, not from the facility boundary) is a rough indicator of the population at risk in the event of fire or explosion at a facility. The population to be counted includes those residing within the two mile radius as well as people regularly in the vicinity such as workers in factories, offices, or students. It does not include travelers passing through the area. If aerial photography is used in making the count, assume 3.8 individuals per dwelling. Assign values as follows:

TABLE 15

VALUES FOR SENSITIVE ENVIRONMENTS (FIRE AND EXPLOSION)

ASSIGNED VALUE =	0	1	2	3
Distance to Wetlands*	>100 feet	--	--	< 100 feet
Distance to Critical Habitat**	> ½ mile	1000 feet - ½ mile	100 - 1000 feet	<100 feet

*Wetland is defined by EPA in the Code of Federal Regulations 40 CFR Part 230, Appendix A, 1980

**Designated by the U.S. Fish and Wildlife Service.

Population	Assigned Value
0	0
1 - 100	1
101 - 1,000	2
1,001 - 3,000	3
3,001 - 10,000	4
>10,000	5

Number of buildings within two mile radius (measured from the hazardous substance, not from the facility boundary) is a rough indicator of the property damage that could result from fire and explosion at a facility. Assign values to this factor as follows:

Number of Buildings	Assigned Value
0	0
1 - 26	1
27 - 260	2
261 - 790	3
791 - 2600	4
>2600	5

8.0 DIRECT CONTACT

The direct contact hazard mode refers to the potential for injury by direct contact with hazardous substances at the facility.

8.1 Observed Incident

If there is a confirmed instance in which contact with hazardous substances at a facility has caused injury, illness, or death to humans or domestic or wild animals, enter a value of 45 on line 1 of the work sheet (Figure 12) and proceed to line 4 (toxicity). Document the incident giving the date, location and pertinent details. If no such instance is known, enter "0" on line 1 and proceed to line 2.

8.2 Accessibility

Accessibility to hazardous substance refers to the measures taken to limit access by humans or animals to hazardous substances. Assign a value using the following guidance:

Barrier	Assigned Value
A 24-hour surveillance system (e.g., television monitoring or surveillance by guards or facility personnel) which continuously monitors and controls entry onto the facility;	0
or	
an artificial or natural barrier (e.g., a fence combined with a cliff), which completely surrounds the facility; and a means to control entry, at all times, through the gates or other entrances to the facility (e.g., an attendant, television monitors, locked entrances, or controlled roadway access to the facility).	

Direct Contact Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Incident	0 45	1		45	8.1
If line 1 is 45, proceed to line 4 If line 1 is 0, proceed to line 2					
2 Accessibility	0 1 2 3	1		3	8.2
3 Containment	0 15	1		15	8.3
4 Waste Characteristics Toxicity	0 1 2 3	5		15	8.4
5 Targets					8.5
Population Within a 1-Mile Radius	0 1 2 3 4 5	4		20	
Distance to a Critical Habitat	0 1 2 3	4		12	
	Total Targets Score			32	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				21,600	
7 Divide line 6 by 21,600 and multiply by 100		S_{DC} =			

FIGURE 12
DIRECT CONTACT WORK SHEET

Barrier (continued)	Assigned Value
Security guard, but no barrier	1
A barrier, but no separate means to control entry	2
Barriers do not completely surround the facility	3

8.3 Containment

Containment indicates whether the hazardous substance itself is accessible to direct contact. For example, if the hazardous substance at the facility is in surface impoundments, containers (sealed or unsealed), piles, tanks, or landfills with a cover depth of less than 2 feet, or has been spilled on the ground or other surfaces easily contacted (e.g., the bottom of shallow pond or creek), assign this rating factor a value of 15. Otherwise, assign a value of 0.

8.4 Waste Characteristics

Toxicity. Assign a value as in Section 3.4.

8.5 Targets

Population within one-mile radius is a rough indicator of the population that could be involved in direct contact incidents at an uncontrolled facility. Assign a value as follows:

Population	Assigned Value
0	0
1 - 100	1
101 - 1,000	2
1,001 - 3,000	3
3,001 - 10,000	4
>10,000	5

Distance to a critical habitat (of an endangered species) is a rough measure of the probability of harm to members of an endangered species by direct contact with hazardous substance. Assign a value as follows:

Distance	Assigned Value
>1 mile	0
1/2 to 1 mile	1
1/4 to 1/2 mile	2
<1/4 mile	3