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Environmental contamination site risk assessment and ranking in Michigan: Revision of the Site Assessment System model. (Volumes I and II)

Carpenter, George Fraser, Ph.D.

Michigan State University, 1991

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ENVIRONMENTAL CONTAMINATION SITE RISK ASSESSMENT AND RANKING IN MICHIGAN: REVISION OF THE SITE ASSESSMENT SYSTEM MODEL

Volume I

By

George Fraser Carpenter

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

1990

ABSTRACT

ENVIRONMENTAL CONTAMINATION SITE RISK ASSESSMENT AND RANKING IN MICHIGAN: REVISION OF THE SITE ASSESSMENT SYSTEM MODEL

By

George Fraser Carpenter

In 1983, the Michigan Department of Natural Resources (MDNR) promulgated the Site Assessment System model (1983 SAS) for the evaluation and ranking of environmental contamination sites as required by Michigan Act 307 of the Public Acts of 1982. This study undertakes review of the model, builds upon the recommendations made by a public committee, and revises and tests the model.

Fifty test sites were selected from the 1989 Act 307 listing of environmental contamination sites in Michigan to test both the 1983 SAS and the revised Site Assessment System (RSAS). All sites were scored using both risk assessment systems and their respective screening

systems. Statistical analyses were conducted to determine the dominant portions of the models and evaluate scores and site rankings.

Four major improvements were developed for RSAS. It has reduced the importance of human impact by awarding points to environmental contamination when human impact has not been observed. The most significant improvement is development of the environmental fate factor which modifies the release potential factor. As a result, a more accurate estimation of contaminant migration potential, after it escapes containment, is derived. The waste quantification methods and the chemical hazard compartment are completely redeveloped and simplified. The chemical hazard score is calculated from equations which relate waste quantity to toxicity. The chemical hazard compartment is also expanded to a level equivalent to the resource compartments. This provides better balance between exposure and toxicological hazard in the concept of risk assessment.

These revisions result in a better identification of significant sites and better discrimination among sites. The RSAS emphasized incidents where contaminant release and migration combined with environmental impact and large waste quantities to give high priority to sites. There was little difference between the systems in identifying the least important sites.

Incorporation of parameters into the screening system which are based on the RSAS has resulted in an improved correlation between the revised screening system score and the RSAS score. Depending on the needs of the Act 307 program and the personnel resources available to conduct site scoring, the screening system could be substituted for the RSAS for site scoring and ranking.

ACKNOWLEDGEMENTS

I would like to thank my Guidance Committee, Professors David Johnson, Harold Prince, Eckhart Dersch, and Leighton Leighty for their advice and guidance in my program. In particular, I would like to recognize my academic advisor and committee chairman, Professor David Johnson, for his patience, willingness to let me go my own way, and readiness to help, make suggestions, or provide solutions when I needed him.

I also wish to acknowledge the support of my family: my wife, Trudy, and my sons, Brian and Scott, for their understanding and putting up with my absenteeism, both physical and mental, during this program. Their support and love made it possible for me to persevere. Over the years, Trudy has helped me learn to write and has been a valuable sounding board and editorial resource.

In addition, I want to thank Lee Kronenburg and Farsad Fotouhi for help in obtaining software and completing some particularly difficult figures as well as Miguel Ortiz for final text formatting and processing.

Finally, I wish to acknowledge four people who helped me along my tortuous path. My late father, Luther C. Carpenter, M.D., who taught me dedication, honesty, and perseverence and encouraged me to find my

own career. My mother, Louise Klein Carpenter, who taught me that learning, understanding, and intellectual growth continue throughout life. Richard A. Laubengayer, Ph.D. who first turned me on to the fascination of science and believed in me. Finally, Nelson H. F. Watson, Ph.D., who rekindled my interest in science, introduced me to the excitement of ecological investigation, and provided many hours of stimulating discussion.

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1.0 Introduction

1.1 Background

There are numerous sites in Michigan which contain hazardous materials and pose serious environmental problems. The improper use, storage, handling, and disposal of these materials may be a danger to the health, safety, and welfare of the people and the environment of Michigan. These sites vary considerably in size, nature, and amount of hazardous substances involved and the nature and severity of the risks present. The contamination sites may include industrial and commercial facilities, landfills, accumulations of drums and tanks (buried or exposed), contaminated soils, surface impoundments, and lakes or streams. Common risks from such sites are long-term contamination of ground water, surface water, and air as well as short-term fire and explosion potential and/or direct contact hazards. Severe short-term hazards must be addressed immediately. Resulting impacts may include acute and chronic toxic effects, destruction of biota and habitat, loss or devaluation of property, and degradation of recreational or scenic resources.

As of March, 1990, there were more than 2600 known or suspected contamination sites in Michigan (MDNR, 1990a). Many of these sites must be evaluated and cleaned up at public expense because a responsible party cannot be identified or denies responsibility, or the property has reverted to the state. Where a party denies responsibility, cost recovery should be pursued after public cleanup if responsibility can be established during the cleanup.

There must be an objective risk assessment system to set priority for public response actions because the risk posed by environmental contamination is more serious at some sites than others and because there is a limited amount of public funds available annually. This system was mandated by the Legislature in the Michigan Environmental Response Act (MERA), Act 307 of the Public Acts of 1982.

The current system, known as the 1983 Michigan Site Assessment System (1983 SAS), was published in November, 1983 and has been applied in the assessment of environmental contamination sites for seven years. An interagency technical committee, consisting of representatives of the Departments of Natural Resources, Public Health, and Agriculture, the Toxic Substance Control Commission and the Legislative Science Office, developed the 1983 SAS.

The 1983 SAS evolved from a 1979 listing of groundwater contamination sites (MDNR, 1979) which was based on the LeGrand evaluation system (LeGrand, 1964) and an attempt by a consultant to develop a rating system. The LeGrand system only considered aquifer vulnerability, waste condition, waste quantity, and nearby population while ignoring waste toxicity, other environmental compartments or known existing exposure to contaminants.

In 1981, a consultant, hired by the MDNR to develop a contamination site ranking system (JRB, 1981). This system was judged to be too simplistic to distinguish among sites. While the environmental compartments were expanded over the LeGrand system, resources, populations at risk, and contaminant quantity and toxicity were inadequately assessed. The MDNR, with substantial negative comments from other agencies and the public, rejected the model and undertook efforts which resulted in the 1983 SAS.

The USEPA Hazard Ranking System (HRS) was also under development at the time of the state model development efforts. The philosophical design of the HRS influenced the 1983 SAS development but differences between philosophies and the uncertainty of when the HRS would be available for use prompted the state to develop an independent system.

The risk assessment model is applied in the ranking of environmental contamination sites for allocation of State funds for remediation. MERA mandates the annual publication of environmental contamination site priority lists. These lists are intended to identify all environmental contamination sites in Michigan and to further identify sites to be cleaned up at State expense.

In the process toward cleanup, a site passes through four steps, site discovery; evaluation, scoring and ranking; preparation of remedial investigation/feasibility study (RI/FS) remediation plans; and final cleanup or remediation. The first two steps are conducted by the Environmental Response Division of the MDNR. State funds can be allocated for the RI/FS activities as well as the final remediation of a site. The preferred approach is to identify a responsible party to undertake the studies and remediation of a site. Without a responsible party, or when a party denies responsibility, the State undertakes the necessary studies and remediation. Site score and rank play a significant role in determining which sites are responded to first, either by the State or by a responsible party. At any stage in the process, if sufficient immediate risk is considered present, emergency removal of contaminants, temporary containment, or restriction of public access may be undertaken by the State.

1.2 Problem Statement

MERA mandated annual review of the risk assessment model. In 1984 and 1985, this review resulted in clarification and guidance reports on use of the model (MDNR, 1984, 1985). In 1986, a site prioritization protocol and an applications manual were prepared to provide further scoring guidance and to incorporate modified forms and instructions into procedural documents (Carpenter, 1986). No model changes were made. With three years of experience in model application, the Groundwater Quality Division (now the Environmental Response Division) decided that a thorough review of the philosophy behind the model should be undertaken. It was also decided that the basic model structure should be examined and that suggestions for improvement, which had been made by department staff and the public, should be evaluated. In October, 1986, the Division convened a public committee to conduct this review. Deliberations of the Site Assessment System Model Review Committee led to a recommendation that the 1983 SAS be revised while maintaining the basic structure of the model (SASCOM, 1988). No action has been taken by the MDNR on that recommendation. In 1990, the Department did accept the screening model conceived by the committee (SASCOM, 1988) and developed in this study as the basis for the risk assessment model to be applied in future environmental contamination site ranking in the State MDNR, 1990b).

1.3 Study Organization

Chapter 2 presents the methods applied in this study to evaluate the 1983 SAS, develop the RSAS, and to evaluate the performance of the RSAS.

Chapter 3 is a review of environmental pollution impact including a discussion of environmental contamination site impact. This review is conducted to identify the concepts important to model performance and structure. The 1983 SAS is described and a number of other risk assessment models, including the HRS, are examined for the differences in form and for ideas which may be of use in the model revision.

Chapter 4 is devoted to identification of areas needing revision in the 1983 SAS identified during its application. It also presents the major revised model improvements and discusses the reasoning and basis for making the revisions proposed in this study.

In Chapter 5, the performance of the 1983 Screen, 1983 SAS, Revised Screen, and RSAS models, in scoring and ranking of the 50 test sites, is evaluated.

Chapter 6 discusses the major conclusions of the study and identifies further areas of study. It also makes a recommendation for application of the model.

2.0 Methods

2.1 Research Objectives

This study acts upon the Site Assessment Model Review Committee recommendation (SASCOM, 1988) to revise the 1983 SAS while maintaining the basic structure of the model. There are three objectives: evaluate the 1983 SAS, revise the model, and test the revision. There are four options for revision: 1) continue use of the 1983 SAS, 2) design an entirely new model, 3) revise inadequate portions of the 1983 model, and 4) recommend adoption of the USEPA Hazard Ranking System model (HRS). The HRS is the model used to evaluate sites in the Federal Superfund Program.

Continued use of the 1983 SAS would ignore the recommendation of the model review committee (SASCOM, 1988). This would have the practical value of avoiding rescoring the several hundred sites already scored and ranked by the 1983 SAS. This would require a decision that the model is adequate for use and has no serious flaws, a view that would be opposed by public commentors (Chrysler Motors, 1989, Conestoga - Rovers, Inc., 1989, and Ford Motor Co, 1989). A compendium of comments and suggestions by MDNR staff (Carpenter, 1988b) demonstrated that there were several areas where the 1983 SAS could be revised. This option was not accepted.

The option to design an entirely new model was not considered necessary by the model review committee (SASCOM, 1988). The committee examined the structure of the 1983 SAS in comparison to other models and concluded that the model was sound enough to not warrant development of a new model. Once adopted, an entirely new model would require adjustment and fine tuning as well as rescoring of all sites.

Revision of inadequate portions of the 1983 SAS is the most practical option. The advantage is that the 1983 SAS model, already proven to be effective, would be improved. A drawback is that all sites will have to be rescored although this burden may not be too great since the much of the information needed for scoring is already in a format suitable for use. The committee (SASCOM, 1988) and MDNR staff (Carpenter, 1988b) recommended this option which is the one pursued in this study.

Adoption of the USEPA HRS is examined in Chapter 3 where the HRS is described. The HRS is considered to have several structural and conceptual flaws which argue against its adoption as a ranking model for Michigan. An advantage of adoption would be that one site score could be used for both State and Federal response systems. However, the State no longer refers all sites discovered in Michigan into the Superfund review process, only those considered especially severe, so few now need to be scored by the HRS for application in the Federal system. Another difficulty is that the USEPA has been trying to revise the HRS since 1987 and has not been able to promulgate a final version. The State should not adopt a model it has not been able to evaluate. also, all sites would have to be rescored for the new model and the ranking lists, with site scores normalized from 0 to 100, would lose discrimination.

2.2 Areas of Revision

Two general areas of technical and structural revision were acomplished. Technical revision included 1) revision of the screening system, 2) development of compartment specific environmental fate factors, 3) development of compartment specific population at risk assessments to include zone of influence concepts, 4) enhancement and redefinition of environmental resource values to balance human exposure, 5) redefinition of aquifer systems and their assessment, and 6) expansion of the chemical hazard score ranges and redefinition of the relationship among contaminant concentration, pure compound, and waste characterization scoring methods. Structural revisions included, 1) incorporation of the screening system into a two-tiered model, 2) separation of emergency risks from longer term site management risks, 3) balancing the chemical score hazard with the resource compartments combined scores, and 4) balancing scores more equitably among compartments according to the risk of exposure to humans and biota.

In revising the chemical hazard score mechanism, regression coefficients built into the Lotus 123 spreadsheet system were used to derive the relationship between waste quantity and chemical hazard score. This allowed derivation of equations to determine the chemical hazard score from the waste quantity and potential toxicity factor for identified contaminants or the waste type for waste characterization scoring. With dual logarithmic scales of waste quantity and chemical hazard score, the equations were found to take the form of a power function:

$$Y = aX^b$$

where Y is the chemical hazard score, a is the intercept of the potential toxicity factor or waste characterization type, X is the waste quantity, and b is the slope of the relationship between waste quantity and chemical hazard score.

2.3 Research Approach

A universe of 50 environmental contamination sites which have been scored using the 1983 SAS (Table 2.1) were selected for model evaluation. The sites were taken from the 1989 Act 307 Priority List (MDNR, 1989) and checked to ensure that up to date data and consistent scoring approaches were used to derive the site score. If additional, more recent data would result in a different 1983 SAS score, the score was changed to reflect constant scoring conditions. If a screening form had not already been completed or could not be found for any of the sites, it was completed before revision of the 1983 SAS score. Standard data packets and site descriptions were developed for subsequent use during the Revised Site Assessment System (RSAS) scoring period and the resulting scores and site descriptions are included in Appendix B.

In an earlier study, 355 sites were evaluated by Carpenter and Warner (1986) to examine the contribution of compartment and parameter scores to total site score. These studies were redone using the 50 test sites in order to ascertain whether the conclusions drawn in that study are

Table 2.1 Test Sites Used to Evaluate the Risk Assessment Models and their Screening Systems

Site Number	Site Name
1	Sanitary Landfill No. 1
2	Peerless Plating
3	Carter Industrial
4	Oliver's Sanitary Landfill
5	Washout Laundry
6	Auto Specialties
7	Story Chemical Co.
8	G and H Landfill
9	Abandoned Tank Farm Lower Harbor
10	Douglas Components
11	Old Koppers Hersey River
12	Pool Co. Area
13	Boardman Lake Canning Co.
14	Du-Laur Products
15	Harsen's Island Barrel Dump
16	Packaging Corporation of America
17	Belfer Drum and Barrel
18	Severance Tool
19	Mt. Elliot Drum Site
20	Ferrysburg Area Gw Contamination
21	Detroit Edison Dredge Spoils
22	E. Columbia GW Contamination
23	Res. Wells Village of Meredith
24	Selfridge Air National Guard Base
25	Herman Radio Tower
26	Trading Post
27	US 41 Birch Creek Res. Wells
28	O'Dell's Gas City
29	Thomas Solvents Rawsonville
30	Thompson Spill
31	Dial Trucking
32	Liquid Disposal Inc.
33	Poseyville Landfill
34	Menasha Corporation
35	Crystal Falls Township Disposal
36	Bates Township Dump
37	Former Rancour Property
38	Tri-City Refuse
39	Darling Road Dump Site
40	Osceola Co.Rd.Commission Reed City

Table 2.1 (cont'd.)

Site Number	Site Name
41	Gw Contamination Penninsula Township
42	Ricci Oil Well Site
43	Saginaw River, Saginaw Bay
44	Thumb Radiator
45	Cannalton Industries Tannery
46	Allied Paper/Portage Creek/Kalamazoo River
47	Whites Bridge Road Area
48	Bay City Middlegrounds
49	Gelman Sciences
50	Torch Lake

valid for the smaller universe of selected sites. As detailed in Chapter 4, the results were consistent with the Carpenter and Warner study and the 50 sites were considered an adequate test universe for this project. Pertinent portions of the comparison between the 1983 SAS and the HRS conducted by Gruben (1989) were reviewed to ensure that important problem areas were identified.

2.4 Analytical Approach

A stepwise regression analysis was conducted on the RSAS site scores to determine the relative importance or dominance of site scores by the various environmental compartments. The stepwise correlation program analyzes compartments in order of their importance or contribution to explaining the total site score. That is, the compartment which contributes most to site score is evaluated first with the next most important compartment being added next, and so on. The R^2 value indicates how much the first compartment and subsequently added compartments account for the trend in the site score, either large or small. Generally, the first compartment analyzed exerts the greatest influence over the total site score and therefore is expected to predict whether a significant or insignificant site score will be derived. As compartments are added, confidence in the prediction of site score and severity increases.

Pearson correlation coefficients were calculated to test the relationship between the 83 Screen and 83 SAS scores and between the R Screen and RSAS scores. The purpose of these analyses was to determine whether the screening systems could be considered predictors for the corresponding detailed system site score. Adequacy of prediction is desirable for effective application of the screening approach which is to detect the more severe sites so that funding and remedial efforts can be directed toward them.

Similar comparisons of site rank between the respective screening and scoring systems were conducted using non-parametric Kendall rank correlation coefficients. The purpose of these analyses was to determine whether the rankings derived by the screening systems could be considered predictors of the ranks derived by the detailed scoring systems. While the screening systems might not predict the site score as analyzed above, they might still predict the site rank which would satisfy the need to identify the most severe sites first.

The final and most important analysis conducted was an evaluation of the two model systems performance in scoring the test sites. The 50 sites were divided into groupings of similar contamination incident (some were evaluated in more than one group) and the performance of the model to provide a representative site score was examined. The performance of both models was also examined to determine whether any of the site groups were underevaluated by either model.

3.0 Literature Review

3.1 Environmental Contamination Sites, Their Existence and Impact

In Michigan, an environmental contamination site is viewed as a location where there has been or there is the potential for a release of a hazardous material(s) which is or may be injurious to humans or the environment. This view is defined in the Michigan Environmental Response Act (Act 307 of the Public acts of 1982) and parallels much of the identification and evaluation of contamination incidents throughout the country and the world. That is, there is a general view that the presence of contaminants is cause for alarm before an impact has been demonstrated. Indeed, because of scientific uncertainty or the inability to statistically demonstrate impact until severe impact has been observed, detection of contaminant release is often called environmental contamination before an impact has been detected.

This principle of uncertainty is illustrated by the current knowledge concerning the generation of greenhouse gases and its relationship to global warming. Laurman (1986) explains that the lack of cause and effect measurements, which would force remediation on the one hand and the resistance to undertaking extreme remedial measures and their costs on the other, leads to a do nothing alternative in global warming. He demonstrates that the latent heat mass of the oceans may significantly delay onset of mean temperature rise but that if we wait until definite correlation between climate change and atmospheric greenhouse gases is shown, irreversible and potentially calamitous temperature rises could occur.

Review of the scientific literature reveals that there are many sites where releases have occurred with measureable negative effect. There are many cases, however, where releases are known but impacts are not quantified and yet site response is underway. Proof of need for response is generally based upon either of two standards, environmental concentrations known or expected to exceed some toxicologically derived chronic or acute impact or environmental concentrations are found to exceed known or estimated background concentrations. In fact, background concentrations are often defined as the cleanup target absent a toxicologically derived target.

Adverse environmental impact is known at contamination sites of widely different nature. Often the impacts have taken time to become evident and may be of such a general or widespread nature that no remedial response has occurred or may ever occur. Nine miles of the Hersey River and Hersey Pond have been contaminated by creosote releases from a wood preserving plant in Reed City, Michigan with a resulting reduced trout fishery (Ferris State University, 1989). Defined as a Michigan contamination site and under investigation by Superfund, cleanup at the abandoned plant will involve removal of contaminated soils and ground water but may not include work in the river other than in the immediate vicinity of the site.

In contrast, Hoffman, et al. (1987) have correlated 15% mortality, decrease in body weight of survivors, an increase in the ratio of liver weight to body weight, and shorter femur length to PCB and polychlorinated dibenzo-p-dioxins in Forster's Terns on Green Bay, Wisconsin. No defined contamination source and the dispersed nature of the contaminants throughout the South Oconto Marsh (which includes a dredged sediment confined disposal facility for sediments from the Oconto River) may result in no remediation for a long time.

Austin and Munteanu (1984) conducted a study of mine tailings impact in British Columbia. They sampled an undisturbed wilderness park lake before, during, and after 14 years of mine tailings input. The study associated the disappearance of numerous phytoplankton species and the increase in density of tolerant diatom species with increases of the heavy metals cadmium, copper, and zinc. Although the decrease in species diversity and species richness was significant and apparently paralleled by zooplankton and fish population alterations, no remedy conclusion was drawn. Another study, concerning herbicide release from rice paddies in the Ishikari River in Japan, detected significant bioconcentration in shellfish and fish (Ohyama, et al., 1986). Shellfish were observed to have disappeared from many areas of the river and to have been absent for 15 years.

Similarly, decline of tree stands and growth in the Black Forest, Germany, have been generally shown to be related to sulfur dioxide, nitrous oxide, and ozone over quite large areas (Juettner, 1986). In this same study, localized severe effects are also believed to be related to volatile organic compounds (VOCs) such as ethylene, propane, butane, benzene, and toluene in proximity to heavily used roads and industrial/municipal emissions. Response in this case will require broad scale emission controls and a change in local and national regulatory structure.

More subtle responses to contaminants have been documented without attribution to specific sources. Rappe et al. (1989) found enlarged hepatopancreas of crabs in relation to polychlorinated dibenzodioxins and polychlorinated dibenzofurans in Scandinavia in general areas of municipal solid waste incineration, steel mills, and pulp mills. Uncertain whether this is a significant negative impact, the authors identified these compounds as the most probable cause because sediment distribution of other contaminants did not coincide with all areas where hepatopancreatic enlargement occurred. DenicolaGuidici et al. (1987) also correlated changes in juvenile/adult population ratios of the isopod, Asellus aquaticus, to sublethal releases of cadmium and copper in the Sarno River in Italy. Similar general health effects of dioxins and furans were demonstrated by Hutzinger et al. (1983). Their own studies and a review of the literature found human health effects such as reduced resistance to colds were related to general levels in the environment, apparently associated with production in metropolitan areas, but could not be related to specific sources or cause and effect impacts.

That releases of dioxins or other contaminants to the air can have serious effects was demonstrated in studies related to an explosion at a chemical plant in northern Italy. Merlo (1983) showed that an aerosol cloud containing TCDD, sodium hydroxide, and 2,4,5-trichlorophenol caused significant chloracne in humans and farm animal deaths in a pattern directly related to the dispersion plume from the plant. Cancerous skin lesions were also elevated although not staistically significant. Although a single emission event, studies by the author contributed to a decision to identify and remove "hot spot" deposition zones.

Much more significant impacts have been observed with no apparent plans to undertake remediation. A coniferous forest was destroyed in a radius of four km from a lead and zinc smelter in Poland (Sienkiewicz, 1986). Substantial levels of lead and zinc in the soils were found to have simplified community structure, reduced species diversity, and increased density of tolerant species, mostly grasses and bryophytes. The author noted that the plant species found were the same as those found on 300 year old mine tailing and smelting dumps in the area. Similar denuding of forest area without indication that remediation will be undertaken has occurred in the vicinity of numerous brine seepage pits associated with crude oil and natural gas exploration and production. Porter Township in Midland County, Michigan, (ERD Porter file), Pullman East Oil Field in Allegan County, Michigan, (ERD Pullman file), and brine ponds in north Dakota (Murphy, et al., 1988) show vegetation die-off and reduced crop yield due to brine migration. At the North Dakota site, releases from 1959 to 1976 resulted in a 500 foot plume, 70 feet deep which has killed trees in a 10 acre area with little dilution of brine concentration. No remediation is planned and little reduction in brine concentration or impact is predicted for many years.

There are also numerous locations where contaminant concentrations have been noted without demonstration of impact. Martel et al. (1986) discovered substantial concentrations of polynuclear aromatic hydrocarbons (PAH) in sediments from the Saguernay Fjord in Canada without conducting the studies necessary to determine environmental impact. The distribution of PAH concentrations between 460 - 8300 ug/kg in sediment were correlated with percent of organic carbon in the sediments. Atmospheric deposition traps accounted for 63% of the sediment burden with several aluminum smelting plants in the immediate area, which discharge wastewaters to the fjord, being blamed for the rest. In calling for sediment cleanup, they cite Conney (1982) who identified benzo (a) pyrene and dibenzo (a,h) anthracene as potent carcinogens associated with human cancer.

In another study, Hernandez et al. (1987) measured 3 - 64.5 ppm lead, and 0.34 - 1.68 ppm cadmium in rose bay leaves in Madrid without determining whether these levels resulted in negative impact. The study also correlated these levels to waste incineration but didn't call for emission controls. In a study of runoff of agricultural pesticides in three Louisiana watersheds, Dowd et al. (1985) concluded that yellow crowned night heron and shad were good monitors of PCB, DDE, and dieldrin without calling for cleanup or pesticide management. They did document that increase in PCB levels in recent years was due to binding to particulate organic matter and downstream migration and not continuing source input. Similarly, Veith et al. (1981) documented significant sediment PCB levels in Saginaw Bay, Michigan without drawing conclusions about the need for cleanup. This notation was sufficient to define the Bay and source Saginaw River as an environmental contamination site (substantial heavy metal concentrations are also known to exist in Saginaw River) in the State environmental contamination site program and to cause the International Joint Commission to define the area as an Area of Concern (IJC, 1985).

Documentation of contaminant concentrations without drawing conclusions concerning the hazard or impact is not restricted to environmental sampling. Wallace et al. (1987) had people in New Jersey, North Carolina, and North Dakota carry air monitors and give breath samples at the end of the sampling days to study VOC concentrations. They also collected air samples in yards of some of the people. Individual monitors detected more VOCs than the yard samples and were related to indoor sources such as smoking as well as dry cleaner and service station visits, occupations involving chemical, paint, and plastic production, and atmospheric emmissions from these sources. Significant correlations were reported for residences near these major point sources, especially in New Jersey. While the purpose was to study the importance of indoor home air exposures to other sources, no attempt was made to determine whether the exposures were significant or whether efforts should be made to modify home, worker exposures, or industrial emmissions.

Goede (1985) essentially considered the Rhine River as a point source discharge to the North Sea in a study of mercury, arsenic, selenium, and zinc in shore birds in the Danish Wadden Sea. Using levels in bird feathers and organs and comparing them to museum specimens collected in 1900 to 1930 and 1960 to 1970, he concluded that substantial rise in body burdens had occurred. This was correlated to decreasing water and sediment concentrations from the mouth of the Rhine to the Wadden Sea and substantial levels of pollution in the river. Unfortunately, no mortality or egg embryology/hatching success studies were conducted so no conclusions of observable impact could be drawn.

Humphrey (1987) correlated PCB, DDT, and DDE blood serum levels to people eating Lake Michigan fish. He noted that studies in 1974 and 1981 showed PCB levels to be 30 times greater in people that consumed fish than in those that did not consume fish. While not calling for limitation in fish use, he did cite Kimbrough (1980) who reported association of PCB with sublethal impacts such as hypertension, vital lung capacity, and arthritis. He raised the point that the long PCB depuration half life could contribute to long term disease but, other than suggesting pregnant women should limit their consumption of Lake Michigan fish, did not call for other use limitations or source control efforts.

Often it is difficult to conclude that observed effects are significant or sufficient to call for remediation. Hertzman et al. (1987) studied workers and surrounding population in the vicinity of the upper Ottawa Street Landfill in British Columbia, Canada and noted a number of sublethal, chronic problems such as bronchitis, skin rashes, dizziness, and headaches. These effects were correlated with on-site exposure and decreased with distance from the landfill, in proportion to reduction in vapor and dust migration. While this facility has been identified as a contamination site in Canada, their inability to find other more serious impacts such as reproductive effects (although angina and heart attack incidence was elevated but not statistically significant) kept them from calling for remedial action.

Another case of general broad detection in the environment was demonstrated in a literature study of the sources and impacts of diethylhexylphthalate. Wams (1987) reported widespread levels of the carcinogen in air, soils, and surface water with high levels occasionally found in association with known generation sources. Little was said about responses at the locations of higher concentration. The study demonstrated another problem in impact detection. The toxicological information presented did not include exposure information so no observable effect level and carcinogenesis thresholds, reported in ingestion rates per kilogram of body weight per day, could not be related to environmental concentrations. Conversion of toxicological standards to environmental concentrations often involves so many assumptions and calculations that the values derived may have limited application.

More direct observations of contaminant release from facilities would help recognize the need for further evaluation or response. Landfill leachate is often noted in general observations about landfills but often is not sampled or investigated because the releases appear minor relative to the size of the landfill or an imagined ground water problem. Tibbles and Baecker (1989) discovered significant levels of phenolic compounds in leachate from a landfill in South Africa and summarized the potential effects from the literature citing benthos and fish toxicity problems, changes in population structure, and taste or odor problems in fish tissue. They noted that the landfill was known to have received wastes from pulp and paper mills, oil refineries, and polymeric resin plants, known phenolic compound producers. They demonstrated, however, that anaerobic conditions in landfills can also produce these compounds, a fact which should cause these releases to receive greater attention.

Contamination incidents are often determined by comparison to some standard with recommendations for mitigation being made before adverse environmental impact has been documented. This approach is common and accounts for the majority of contamination sites on both the Michigan contamination sites list as well as the Superfund National Priorities List. The definitions of hazard are based upon some predetermined toxicity scales such as Sax (1989) or Maximum Contaminant Limits (MCLs) published by the USEPA (1989) pursuant to the Safe Drinking Water Act. A comparable set of standards are the permissable limits published by the World Health organization (WHO) cited by Dissanayake et al. (1987) while evaluating canal water and drinking water wells in Sri Lanka. Identifying lead levels up to 850 ug/l and cadmium up to 310 ug/l in canal and well water (relative to WHO permissable limits of 100 and 10 ug/l respectively) their studies called for elimination of canal water for potable purposes. Effluent limitations were also recommended for source industries identified during the study period.

Parks and Hamilton (1987) documented a fish consumption standard contamination situation in the Wabigoon/English River system in relation to a chlor-alkali plant. Finding elevated concentrations in water, sediments, and fish, they noted pike tissue levels above consumption advisories. Demonstrating that methyl mercury was partitioning between water and sediments, they called for remediation and suggested clay overlayering to contain the mercury rather than sediment removal.

A controversial Superfund purchase of private homes and contamination area access restriction was undertaken at Times Beach, Missouri strictly in relation to a defined toxicological standard. Belli et al. (1989) reported TCDD soil levels up to 252 ug/kg (ppb) relative to a risk based standard of 0.005 ppb for the suspect carcinogen. The contamination had resulted from spraying unpaved roads with waste oil and other chemicals in 1972. The sprays contained TCDD. Other Superfund sites where responses occurred after comparison to MCLs or other standards were reported by Harkov et al. (1985). Volatile organic compounds (VOCs) were found in municipal drinking water wells at Battle Creek and Charlevoix, Michigan, Bedford Massachusetts, and Williamstown and Lyndonville, Vermont. At Williamstown, the level of detection initially causing response was barely above the detection limit when the site was listed. This identifies another standard commonly applied for organic chemicals. Background levels are assumed to be zero so any detection automatically earns the designation as a contamination site. This occurred, for example, at all of the residential well sites listed in Table 1.1 in their initial discovery as environmental contamination sites in the Michigan program.

Migration of VOCs from six hazardous waste sites in New Jersey were reported by Harkov et al. (1985) to have been directly involved in the decision to list the sites on the Superfund National Priorities List. With no estimate of impact other than measured concentrations of several solvents in the air, in spite of daily cover, and the presence of large quatities of waste, the sites were initially listed simply because background thresholds were exceeded.

Significant impacts have triggered environmental cleanups. One famous Superfund site resulted from discovery of adverse impact to nesting bird populations in Kesterson Reservoir, California. Selenium concentrations in the Reservoir and surrounding marshes were blamed for high hatching failure, embryo malformation, and beak defects in several species of waterfowl and wading birds (Hoffman et al., 1988, Ohlendorf et al., 1987 and 1989, and Williams et al., 1989). Selenium contamination occurred due to concentration of spent irrigation waters in marshes constructed as wetland recovery projects. Naturally occurring soil levels were mobilized during irrigation, possibly under slightly acidic conditions, and discharged to the reservoir. Impacts were presumably the result of dietary intake. Studies in grassland voles were inconclusive (Stoeckle, 1986). Selenium was elevated in the voles and no pregnancy was observed compared to a control population while one case of a malformed embryo was observed. However, early drying conditions in the grasslands were cited as another possible explanation for the low pregnancy rate and the author noted that the test population seemed less susceptible to selenium induced embryonic abnormalities. A study to identify human impacts concluded that there was no adverse impact (Fan, et al. 1988). In fact, while advisories against consumption of both waterfowl and fish had been issued, no change in blood levels were observed compared to a control population. It is possible that the advisories had worked and exposure had not occurred. Microbial methylation of selenium to dimethylselenide (which is volatile) has been instituted as part of the final remedy at Kesterson (Thompson, et al., 1989). The flooding of the marshes has been discontinued until the site is remediated and a solution to the transport of selenium is found.

A case of impact induced mitigation was reported in Wales in relation to lead mining (Davies, 1987). Lead as well as zinc and copper mining goes back to before Roman occupation although the main active period was 1750 to 1900. Direct disposal and acid leach from tailings piles had resulted in severe impact in the 1920s with recovery apparent in the 1970s due to mitigation efforts to isolate the tailings from the watershed. Several events of stream benthos and fish destruction in recent years were documented when old tailings piles were breached or lining and leachate systems failed to operate. Long term mitigation efforts are underway, and were called for in the study.

3.2 Risk Assessment, What Is It?

Risk is generally viewed as the possibility of suffering some adverse effect. Its consideration pervades society and governs much of what we do from investing in the stock market to taking a chance on getting a traffic ticket. There are numerous popular lists of daily societal risk similar to that shown in Table 3.1 (taken from Allman, 1985) and people are accustomed to thinking that the risk of dying in an airplane or car accident compared to getting cancer from smoking is small enough to take a chance on. This demonstrates the form we are accustomed to seeing risk in as well: that of a probability. As shown in Table 3.2, the probability of contracting cancer by exposure to a pure compound is highly variable depending on the compound. The ability of the public or an individual to decide the acceptability of such a risk is limited (Travis and Hattemer-Frey, 1988). The problem facing a regulator in this context is finding the "de manifistes" level of risk, i.e. the ceiling above which events are inherently unsafe and should be regulated without regard to cost. As can be seen from Table 3.2, determining this level for different compounds when risks range from nearly 1 in 10 (arsenic from high-copper smelters) to 5 in 1 billion (dimethylnitrosamine) and combining multiple contaminant risk at a site can be very difficult.

There is, however, another form of risk assessment presentation beside probability, the acceptability or how safe approach (Lave, 1987). Determining these levels of acceptability is a two-step process (Rowe, 1977 and Dourson and Stara, 1983). First, there must be a compilation

Table 3.1 Common Daily Societal Risks

Travel	Mode	Number of Deaths per Billion Miles
	Car	10610.38
	Scheduled Airlines	10.61
	Bus	0.38
	Passenger Trains	0.36
Health	Exposure	Rate in Population (%)
	Heart Disease	2.6
	Cancer	1.2
	Suicide	0.89
	Emphysema	0.78
	Homicide	0.68
	Drowning	0.26
	Fire	0.26
	Firearm Accident	0.08
	Syphilis	0.01
	Lightning	0.004
	Tornado	0.003

Adapted from Allman, 1985

Table 3.2 Selected Risk Based Exposure Concentrations and Carcinogen Status for Some Common Environmental Contamination Site Contaminants

Compound	TLV/TWA[1] ppm	TLV/TWA[1] mg/m^3	WRL[2] ug/l
acetone	750	1780	700
ammonia	25	18	-
benzene*	10	30	1.0
benzo (a) pyrene*	-	2	0.003
bromine	0.1	0.7	-
cadmium	-	0.05	4
carbon tetrachloride*	5	30	0.01
chlorine	1	3	-
chlorobenzene	75	350	140
chloroform	10	50	6
chromium VI*	-	0.05	35
DDT	-	1	0.1
1,1 dichloroethane	200	810	700
1,2 dichloroethane*	10	40	0.4
1,1 dichloroethene	5	20	300
trans 1,2 dichloroethene	200	790	140
ethylbenzene*	100	435	30
formaldehyde*	1	1.5	1
lead*	-	0.01	5
mercury	-	0.01	2
methylene chloride*	50	105	5
naphthalene	10	50	40
nitrobenzene	1	5	-
ozone	0.1	0.2	-
PCBs*	-	-	0.02
phenol	5	19	300
styrene*	50	215	0.1
tetrachloroethylene*	50	335	0.7
toluene	100	375	40
trichloroethylene*	50	270	3
vinyl chloride*	5	10	0.02
xylene*	100	435	20
zinc	-	-	0.02

1 Air Threshold Limit Values/Time Weighted Averages
2 Drinking Water Risk Level
* Carcinogen in Michigan Critical Materials Register

Adapted from ACGIH, 1988; Flaga, 1990; Anderson et al., 1983 and comparison of dose-response or effect data, including available human data, to obtain a no effect level. Second is the assessment of these data to provide "safe" or acceptble levels or at least to define the risk. These assessments are conducted applying safety or uncertainty factors, generally in a conservative manner (Lave, 1985). Often the margins of uncertainty are quite large because numerous calculations are involved, there can be considerable variability among similar experiments, or because they are extrapolated from populations quite unlike man or the target population to be protected (Lave, 1985 and Dourson and Stara, 1983).

In science we are most accustomed to seeing risk in terms of health or toxicology, again with probabilities associated with risk of developing a particular disease. Toxicology and risk are not synonomous, toxicology being the study of the toxicity of a particular compound which is reported in terms of a probability or risk value (Klassen, et al., 1986). For example, in acute toxicity studies, the result of an experiment is reported as the LC50 or EC50, the concentration at which the end point or effect is observed in 50% of the test population (Rand and Petrocelli, 1985). In chronic toxicity testing, which evaluates the possibility of adverse effects under long-term exposure at sublethal concentrations, results may be reported as either concentrations which produce a sublethal response (such as a 50% reduction in reproductive success) or as the concentration at which no adverse effect can be detected. This lack of measurable response levels can be reported as the maximum acceptable toxicant concentration (MATC) or the no observable effect level (NOEL) (Mount and Stephen, 1967). These or other toxicological properties form the basis for a risk assessment, the decision that some concentration or event is safe. This is the essence of conventional risk assessment, that there is some decision made about the acceptable or safe level of exposure (Rand and Petrocelli, 1985 and Klassen, et al., 1986). Risk assessment, then, requires knowledge of the toxicity or effect of a contaminant or event and a decision concerning its acceptability. If the decision is made to define the acceptable level as the NOEL, then the assessment becomes one of adequacy of the toxicologiclal endpoint detection.

3.3 Contamination Site Evaluation: Risk Assessment or Hazard Assessment?

As discussed above, classical risk assesment is the combination of assesssments of objective risk in the form of probability computations. These are often transformed into the context of subjective risk by comparison to commonly perceived or understood hazards. Subjective risk estimation is derived by evaluation of the consequences of the outcome of the event and depends on the perceptions of the public or an assessor (Rowe, 1977). Hazard implies an impact or consequence of an event without necessariy putting a chance or probability on the occurrence of the event. Thus, the event itself is seen as the hazard and includes descriptions of methods of contaminant migration, if contamination has occurred, and the value of the size of human or environmental resources which may be impacted. This descriptive hazard approach is known as a structured value assessment system (Yosie, 1979 and USEPA, 1988), the factors governing exposure, contaminant migration, value of a resource, target identification, land use or whatever is being assessed, are given a value scale according to the perception of importance of each parameter by the individual or group designing the system.

Often, identification of risk without a determination of acceptability is insufficient to make a decision whether to take that risk. This is the concept of risk generally practiced in connection with environmental contamination sites: defining the problem to the extent necessary to deetermine whether to attempt to reduce the risk. There are two basic approaches in this area typified by the Federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, commonly known as Superfund) on the one hand and the Michigan Environmental Response Act (Act 307 of the Public Acts of 1982) on the other.

In Superfund, a level of acceptability has evolved in the National Contingency Plan (USEPA 1988) where a threshold score of 28.5 in the HRS is required before a contamination site can qualify for the National Priorities List (NPL) and Federal investigation and cleanup funding. The selection of the threshold was arbitrary (a decision was made in a taxi heading to a congressional hearing that 750 sites should be on the first NPL which corresponded to the 28.5 HRS score) and the agency says that sites scoring below the threshold may still be contamination sites but that they should be the responsibility of the States. Regardless of this disclaimer, responsible parties repeatedly insist that they are not contamination sites because their property has fallen short of the 28.5 threshold (Chrysler Corp., 1989, Ford Motor Co., 1988, 1989, TRW, 1989) and they should be exempt from Act 307 at the State level. At the public hearings and in written comments to the proposed Act 307 Administrative Rules these same firms and a consultant (Conestoga-Rovers, Inc., 1989) argued for a similar threshold in the State system.

The opposite viewpoint is seen in many State programs, including Michigan's, where the decision of whether a site is an environmental contamination site is based upon statutory definition, whether there has been or there is a potential for a release of a substance which may be injurious to the public or the environment from a discarded material. The absence of a threshold and use of a statutory definition removes the level of acceptability from the risk assessment review.

3.4 Model Structure

Environmental contamination site risk has two elements. These are toxicity of contaminants on site and the chance of human or environmental esposure to the contaminants. The toxicity parameter has been described above. The other aspect, however, involves whether the target is exposed to the concentration exhibiting the particular effect (Rand and Petrocelli, 1985 and Giese, 1984). Exposure is the chance that the target will come in contact with the compound at the level of toxicity concern. Exposure is generally defined in terms of the migration of a contaminant to a target. Contaminant migration and environmental resource target identification are common features of the studies cited above and are relatively easy to place a value on. Other parameters describe the physical relation of a waste to an environmental resource such as distance to surface water, and size of the human population at risk. These targets and descriptors are difficult to define in terms of a probability and are better assessed by perceived values.

Some parameters, such as chance of a contaminant escaping containment or chance of contaminant penetration of the unsaturated zone or a confining layer based upon layer permeability, can be described by a probability function. These may be difficult to estimate. For example, how does one measure the probability of a barrel rusting and leaking? In addition, it would be difficult to combine a probability parameter with a perceived value parameter without distorting the relationship among parameters.

There are two combinations of these elements, shown in equations 1 and 2 below:

$$\text{Risk Assessment} = \text{Exposure} + \text{Chemical Hazard} \qquad \text{Eq. 1}$$

$$\text{Risk Assessment} = \text{Exposure} \times \text{Chemical Hazard} \qquad \text{Eq. 2}$$

where chemical hazard is a description of the toxicological information known or the inherent hazard of the contaminant.

Equation 1 is generally used to combine exposure parameters of differing units of measure in the structured value approach (Yosie, 1979 and

USEPA, 1988) while equation 2 is commonly applied when exposure parameters are measured in terms of probability (Conestoga-Rovers, Inc., 1989). The different units of measure are derived in the more common method of environmental contamination site risk assessment, the structured value assessment system. The additive nature is used in order to avoid over emphasis of the impact of the parameter relative to other parameters. The multiplicative nature is appropriate to combination of probabilities and equation 2 where the relative importance of parameters is controlled in a normalized scale.

It has been argued (Conestoga-Rovers, Inc, 1989) that risk assessment models must adhere to the format of Equation 2 because this is the classical probabilistic risk model format. As discussed above, when the risk parameters are not reported in terms of probabilities, the format of Equation 2 becomes a liability because it distorts the relationship among parameters. For example, in each environmental compartment or route of the HRS, a toxicity and persistence score of up to 18 is derived from a matrix. This is multiplied by either an observed release value or by a migration potential value and then multiplied by a waste quantity value and target values for population at risk and environmental parameters. The result is that the chemical hazard parameter, an important part of either Equation 1 or 2 above, is trivialized relative to the various exposure parameters. This is discussed further in the discussion about keeping the 1983 SAS format.

In fact, the HRS and other models applying the multiplication format are still not adhering to the concept of Equation 2 because the parameters are not presented in the form of probabilities or logarithmic relationships. The parameters are developed within the structured value relationship concept of risk assessment and given weights considered valid by the model writers. For example, to be scored as a logarithmic function, population at risk would have to follow a scoring sequence such as

Population Range	Score
1 - 10	1
11 - 100	2
101 - 1,000	3
1,001 - 10,000	4
.	.
.	.
.	.

Instead, the scoring scale follows the sequence:

Population Range	Score
1 - 50	2
51 - 100	4
101 - 500	6
501 - 1,000	8
1,001 - 10,000	10
>10,000	12

It is also argued by the advocates of Equation 2 (Ford Motor Co., 1989, and Conestoga - Rovers Inc., 1989) that the method of root mean square combination of compartment scores in most environmental contamination site models is done to fit the format of Equation 2. This is argued because the format of Equation 2 when converted to a combination of probabilities becomes:

$$\text{Risk Assessment} = (E_1 \times E_2 \times E_3 \times \ldots) \qquad \text{Equation 3}$$

where E_1, E_2, E_3, ... are probability based parameters such as release potential, migration potential, toxicity, population at risk or other exposure or toxicity parameters.

Equation 3, when converted to log structure takes the form of Equation 4 below:

$$\log(\text{Risk Assessment}) = \log(E_1) + \log(E_2) + \log(E_3) + \ldots. \quad \text{Equation 4}$$

The summing of logs is equated to the summing of the squares of compartment scores followed by taking the square root of the sum of the squares. This is not the same operation. The root mean square method of combining compartment scores as practiced in the 1983 SAS or the HRS is not adding logs or multiplying parameters. It is placing greater emphasis upon the highest scoring compartment by combining the compartment squares.

3.5 1983 SAS Model Description

The 1983 model is a structured value assessment system based upon perceived risk and value of the potentially affected resources. It is not a true risk assessment based upon measured toxicological response to exposure. Instead of calculating the probability of a specific event, as in the toxicological form of risk assessment, a ranking score is derived. The score is based on the perceived value of the model parameters and their relative importance to risk. A schematic plan of the 1983 SAS model is shown in Figure 3.1.

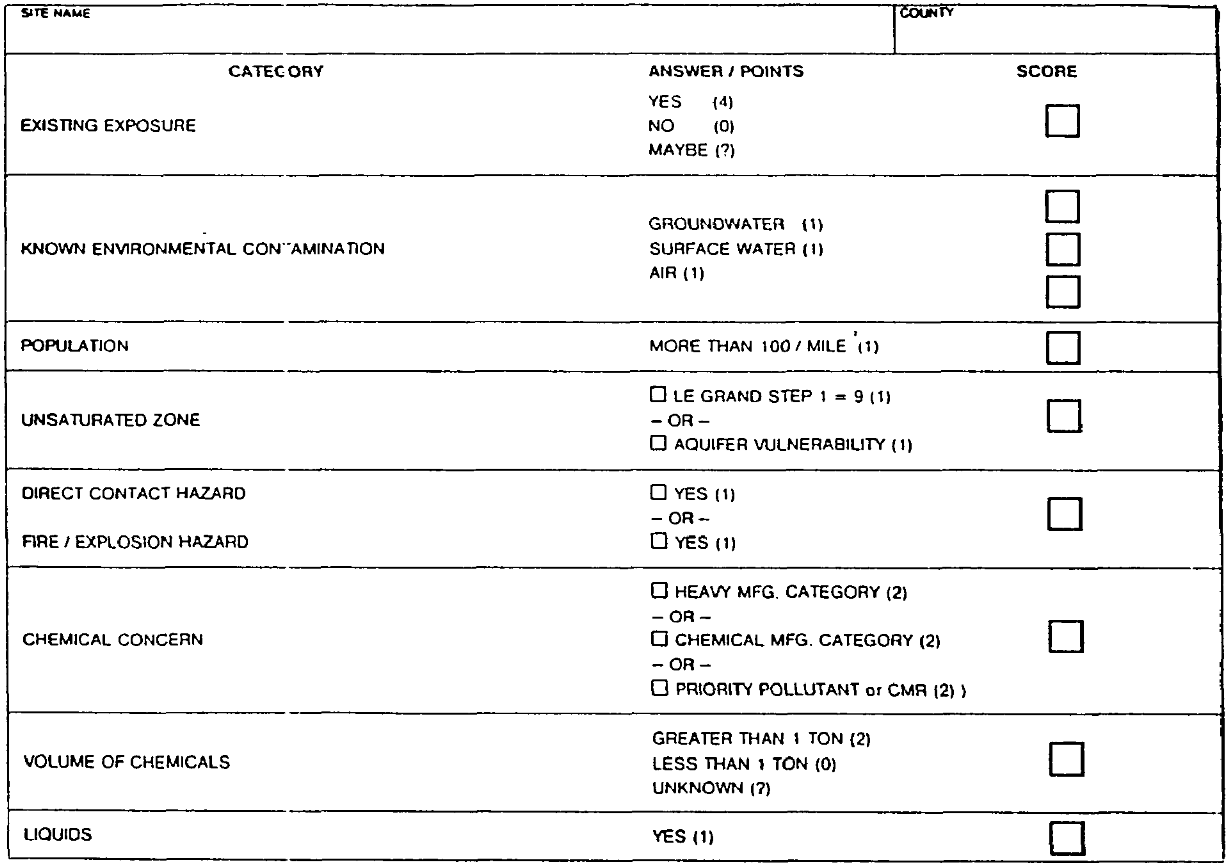
Using a system devised in 1984, each contamination site is screened for relative severity at the time of discovery. A schematic plan of the screening system is shown in Figure 3.2. This screening procedure was developed because far more contamination sites were discovered than could be scored with the professional staff available and insufficient data were available to derive valid scores for many of them. Therefore, only sites screened at a value of 9 or greater out of a possible 15 points are scored using the 1983 SAS.

The 1983 SAS model divides site risk assessment into two portions consisting of 1) routes via which the public and/or the environment may become exposed to contamination and 2) an analysis of the chemical hazard of the contaminants on site. The routes of exposure considered are ground water, surface water, air, direct contact, and fire and explosion. Chemical hazard is assessed in terms of direct toxicity to

Category \ Route		Groundwater			Surface Water			Air			Direct Contact			Fire and Explosion		
		Rating Factor	Range of Scores	Site Score	Rating Factor	Range of Scores	Site Score	Rating Factor	Range of Scores	Site Score	Rating Factor	Range of Scores	Site Score	Rating Factor	Range of Scores	Site Score
Potential Exposure	Release Potential (RP	Release Potential	0-2		Release Potential	0-2		Release Potential	0-2		Release Potential	0-2		Release Potential	0-2	
	Environmental Exposure (EnE	Unsaturated Zone	0-100		Distance to surface water	0-40		Mobility	0-70		Accessibility	0-80		Ignition Source	0-50	
					Site Slope	0-40		Site Activity	0-30		Attractiveness	0-20		Waste Separation	0-50	
					Flood Potential	0-20										
	Targets (T)	Population at Risk	0-100		Population at Risk	0-100		Population AT Risk	0-100		Population AT Risk	0-100		Population	0-100	
					Drinking Water Population	0-40										
					Wetlands	0-10										
		Saturated Zone	0-60		Cold water Fish	0-15								Wetlands	0-10	
					Warm water Fish	0-10										
Potential Exposure (PE Score -(EnE+T) x RP			0-520			0-530			0-400			0-400			0-420	
Existing Exposure	Existing Exposure (E&E	Existing Exposure	0-250		Existing Exposure	0-250		Existing Exposure	0-240							
								Odor	0-10							
Route Score PE + E E			0-770			0-780			0-650			0-400			0-420	

Route Subscore (SS)	$(GW^2 + SW^2 + Air^2 + DC^2 + FE^2)$	$[(770)^2 + (780)^2 + (650)^2 + (400)^2 + (420)^2]^{1/2}$	0-1,400	
Chemical Hazard	Chemical Hazard (CH	Range of Scores 0-600		
		Site Score CH + SS	0 - 2,000	

Figure 3.1 Schematic Diagram of the 1983 Michigan Site Assessment System (Taken from MDNR, 1983)



SITE NAME		COUNTY
CATEGORY	ANSWER / POINTS	SCORE
EXISTING EXPOSURE	YES (4) NO (0) MAYBE (?)	☐
KNOWN ENVIRONMENTAL CONTAMINATION	GROUNDWATER (1) SURFACE WATER (1) AIR (1)	☐ ☐ ☐
POPULATION	MORE THAN 100 / MILE' (1)	☐
UNSATURATED ZONE	☐ LE GRAND STEP 1 = 9 (1) – OR – ☐ AQUIFER VULNERABILITY (1)	☐
DIRECT CONTACT HAZARD FIRE / EXPLOSION HAZARD	☐ YES (1) – OR – ☐ YES (1)	☐
CHEMICAL CONCERN	☐ HEAVY MFG. CATEGORY (2) – OR – ☐ CHEMICAL MFG. CATEGORY (2) – OR – ☐ PRIORITY POLLUTANT or CMR (2))	☐
VOLUME OF CHEMICALS	GREATER THAN 1 TON (2) LESS THAN 1 TON (0) UNKNOWN (?)	☐
LIQUIDS	YES (1)	☐

Figure 3.2 Schematic Diagram of the 1983 Screening System (Taken from MDNR, 1983)

humans and biota as well as flammability and reactivity of the contaminants.

Each environmental route is divided into existing exposure and potential exposure components. Existing exposure is scored up to a maximum of 250 points in the ground water, surface water, and air compartments but is not scored in the direct contact or fire and explosion compartments. The existing exposure component scores the known human exposure to contaminants and is largely limited to contaminated drinking water supplies although fish consumption advisories could result in 50 points in the surface water compartment and off-site odor is allowed 10 points in the air compartment.

The potential exposure component assesses the release potential of contaminants, their likelihood of migration to an environmental resource (measured in a category called environmental exposure) and the value of the resource, collectively called targets. The release potential factor (ranging from a value of 0 to 2) is used as a multiplier of the sum of the environmental exposure and targets parameters in each route. Its value was based upon the physical state of the contaminant at the time of its release or disposal as shown in Table 3.3. To derive a release potential factor for each route, the adequacy of the containment structure containing each waste is assessed. If the containment is inadequate, the release potential factor from Table 3.3 is fractioned according to the proportion of the total site waste in the containment structure, with the fractions totaled across all containment structures for each route. If containment is adequate, the release potential

Table 3.3 1983 Site Assessment System Release Potential Factors Based Upon the Physical State of the Waste at the Time of Disposal

Physical State	Score
Solid	1.0
Semi-solid	1.5
Liquids and Gases	2.0

Examples		
Landfill-demolition waste	1.0	
general waste	1.25	
industrial waste	1.5	unless liquids are known to have been disposed
organic chemicals	2.0	
Waste Piles	1.0	
Sludges	1.5	
Salt Storage Piles	1.0	
Surface Impoundment	2.0	
Gravel Pits	1.0/1.5/2.0	depending on waste
Drilling Mud Pits	1.5	
Holding Ponds	2.0	
Containers	1.0/1.5/2.0	depending on waste
Wells (dry, oil, injection)	2.0	
Spray Irrigation	2.0	
Fertilizer Application	1.0/2.0	depending on form
Road Brining	2.0	
Spills	1.0/1.5/2.0	depending on waste
Septic Tanks	2.0	if receiving non-sanitary waste

fraction for the containment structure would not be included in the route total.

The environmental exposure parameters are intended to be a measure of the ease of a contaminant to migrate to the targets and are scored from 0 to 100 points in all routes. In ground water, one parameter, the unsaturated zone is evaluated. The score is derived from a matrix which considers the nature of the soil overlying an aquifer and its thickness. This includes the water table and all soils overlying the aquifer, as well as the confining layer, because the well logs used in the evaluation usually do not record the presence of the water table. If the water table is documented, it may be scored as the target aquifer. Because of the single parameter nature of this score, the common perception is that the unsaturated zone is being scored for its inherent value. The score, however, is for its ability to impede contaminant migration.

In the Surface water route, the 100 points is divided (40, 40, and 20) among distance to surface water, intervening site slope from the waste to the surface water body, and the flooding potential of the land where the waste resides. No provision is made for ground water contamination of surface water and migration is assumed to only be in liquid form by overland flow.

In the air route, the mobility of the material (up to 70 points) again depended on the physical state of the contaminant whether it is liquid, solid, or sorbed on fine or coarse particles. The remaining points are allocated according to the amount of site activity and the chance a material will be stirred up, suspended, or "tracked out". Accessibility (80 points) is the primary environmental exposure parameter in the direct contact route and is based on the nature of the containment structure. Open lagoons or leaking barrels are scored while covered waste or sealed barrels are not. The remaining points (attractiveness) are based on the appearance of structures to attract site use such as soil piles or standing water and whether schools or playgrounds are nearby. For fire and explosion, if an advisory has been issued, the question is whether there is a source of spark or flame on site and how separated various wastes are from each other (on only one occasion has this parameter been scored - at Cannalton Industries, where the waste spontaneously ignites (Appendix B)).

In targets, population at risk is a constant in all compartments, ranging from 0 to 100 points. However, population ranges are different among the environmental pathways. For example, a ground water drinking population of 12,000 people attains the maximum score, 100 points, while a surface water bathing population or direct contact population (which has to migrate to the waste) has to be greater than 20,000 people before the maximum score is attained. The air and fire and explosion populations only have to be 10,000 people but the air compartment requires detection of a contaminant at the site boundary while an advisory must be issued by a fire marshall before a site can be scored in the fire and explosion route. Seldom did any of the compartments other than ground water receive a significant population at risk score (Carpenter, 1988b).

The surface water compartment has an additional 40 point scale for surface water drinking water population, which, although not often scored, did yield significant scores at some sites. Other targets, beside population at risk, are the saturated zone in the ground water compartment and wetlands and warm water or cold water fish in the surface water compartment. The saturated zone is scored up to 60 points for the inherent value of a target aquifer which could be tapped for drinking water. Wetlands and warm water fish can receive 10 points apiece while cold water (salmonid) fisheries receive 15 points (the warm water fishery points are then disallowed). No target assessment other than population at risk is made in the air and direct contact compartments. In the fire and explosion compartment, wetlands are again given 10 points.

When designing the model in 1983, the committee chose to separate chemical hazard from the exposure routes, in part, because it believed that the inherent hazard of the contaminants needed to be addressed in all aspects of toxicity (acute and chronic toxicity, mutagenesis, carcinogenesis, teratogenesis, other biota effects). If combined with the exposure routes, the analysis of chemical toxicity would need to reflect the means of exposure on a route by route basis (for example, ingestion and bathing for ground water and surface water potable water sources, swimming for surface water, and inhalation but not ingestion for air) each of which would require independent toxicological evaluation. Of a secondary nature, in cases where specific contaminants have not been identified on site, the default chemical hazard scoring method is based on the industry or facility type, an analysis which does not lend itself to the different exposure routes.

Therefore, two methods of chemical hazard scoring were devised, known contaminant with known or calculated quantity of contaminant on site and waste type characterization with estimated quantity. For known contaminants, a potential toxicity factor is derived by department toxicologists applying a variation of the Critical Materials Register (MDNR, 1988) evaluation methods which take the parameters mentioned above into account. A score is derived by entering Figure 3.3 with the potential toxicity score and waste quantity and reading a value. A de minimus value is applied: if any contaminant is present at less than 1 kg, it is not scored. This method rapidly loses precision if the quantity of pure contaminant is not known, with calculated quantities, estimated quantities, or estimated quantities of waste which contain the contaminant in some concentration being freely substituted. Gross estimates of waste quantity used in the release potential calculations are often substituted. A separate score is derived for each contaminant and the resulting scores totaled until a maximum of 450 points is reached.

The other major chemical hazard scoring method, waste characterization, is easy to apply and accounts for nearly 70% of the site scores (Carpenter, 1988b and Gruben, 1989). In this method, the waste in each containment structure is characterized in Table 3.4 according to its type or source and a score is derived from Figure 3.4 using a general

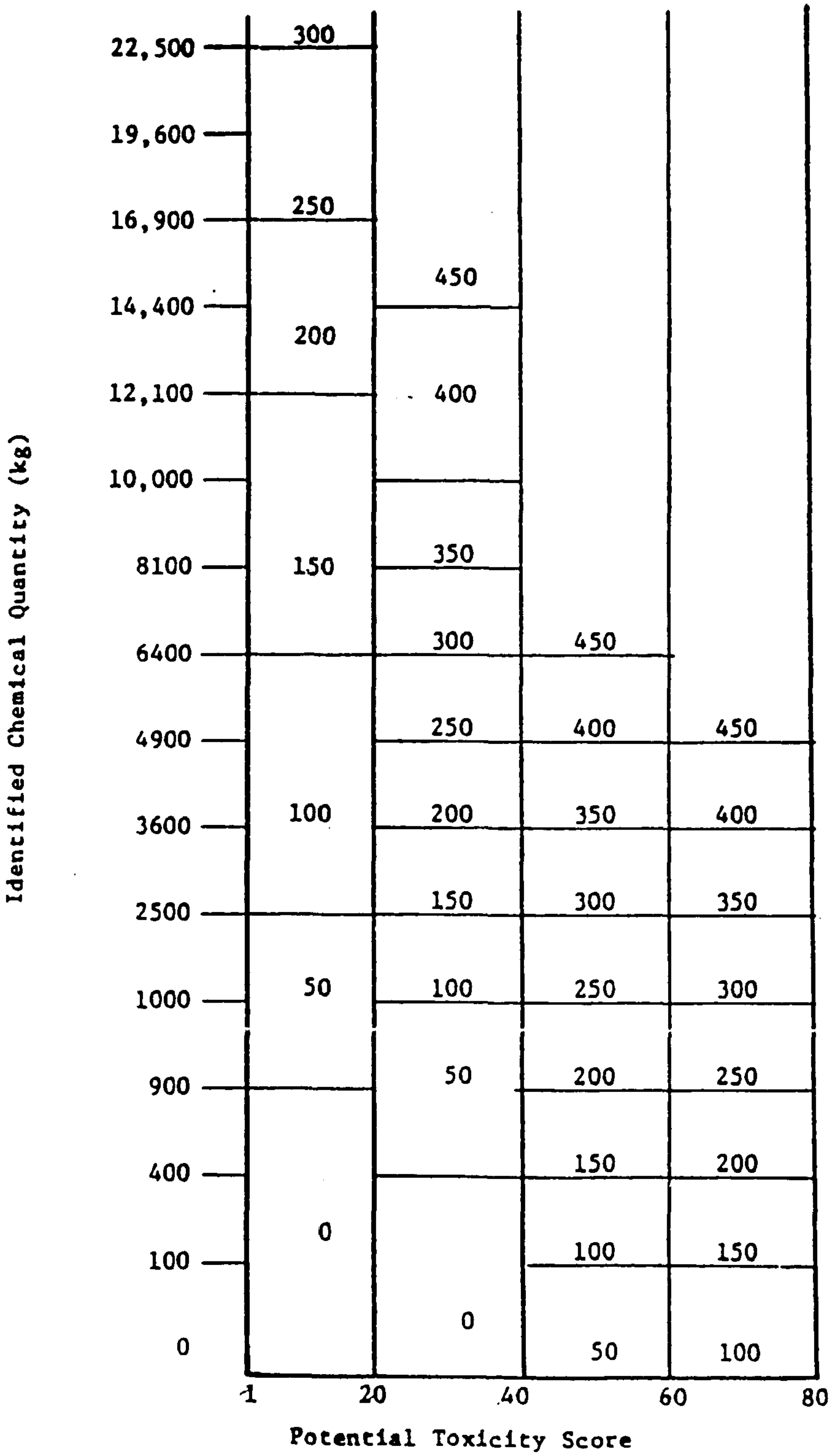


Figure 3.3 1983 Site Assessment System Identified Contaminant Chemical Hazard Scoring (Taken from MDNR, 1983)

Table 3.4 1983 Site Assessment System Waste Characterization Categories

Category	Examples
Domestic and Commercial Wastes	-Refuse -Small quantities of spent commercial chemical products (cleaning/degreasing solvents, household pesticides)
Light Manufacturing and Assembly: operations not expected to generate large quantities of highly toxic flammable or reactive chemicals	-Food and kindred products -Printed circuit production -Electronics equipment -Printing and publishing -Apparel -Lumber -Pulp and paper -Clay and glass -Appliance, furniture, equipment, etc. assembly -Hospitals, clinics
Heavy Manufacturing, Fabricating, Milling, Refining: operations expected to generate large quantities or concentrations of highly toxic, flammable, or reactive organic and/or inorganic chemical containing wastes; i.e. heavy metal sludges, waste dyes, resins, corrosive pickle liquors, refining sludges, spent solvents, paints, etc.	-Primary metals including foundries, smelting, and refining -Metal plating and finishing -Rubber and plastics -Transportation including motor vehicles, aircraft, and associated parts -Machinery -Textile finishing and dying -Leather tanning/dying -Battery manufacturing
Chemical Production, Manufacturing, Formulating, and Refining: operations expected to generate waste pure or off-specification chemical products and the raw chemicals and intermediates used in their production	-Pesticides -Pharmaceuticals -Paint and allied products -Organic and inorganic chemicals -Explosives -Petroleum refining and re-refining -Dyes and pigments

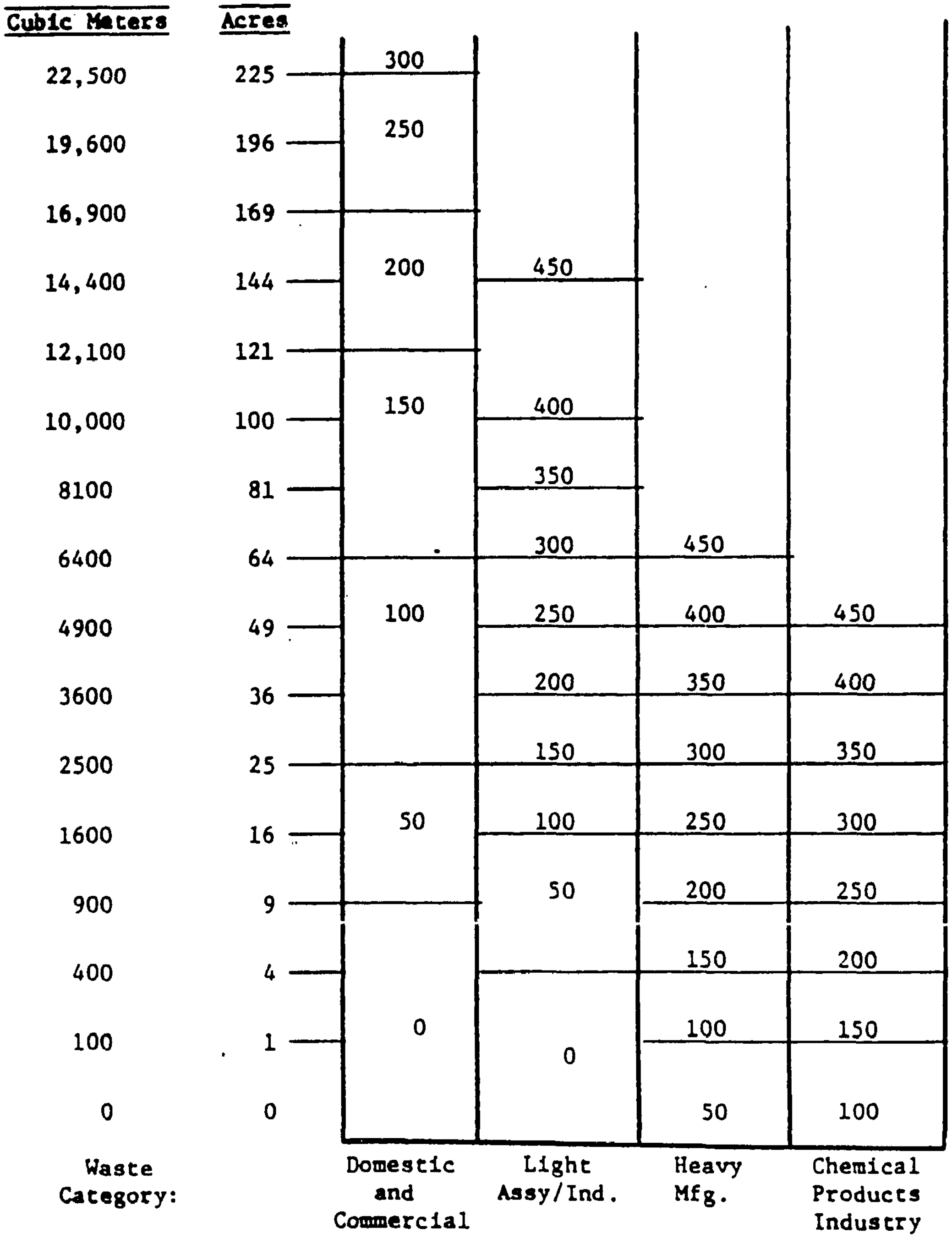


Figure 3.4 1983 Site Assessment System Waste Characterization Chemical Hazard Scoring (Taken from MDNR, 1983)

quantity estimate of acres or cubic meters of waste. The scores for all containment structures are added, again to a maximum of 450 points.

If both known and characterized wastes are on site, the scores (if less than 450 points) are combined in proportion to the waste quantity in each scoring method. To accomplish this combination, common units have to be derived, usually by applying the gross estimates derived in the release potential estimation method.

A third method of chemical hazard scoring, based strictly on concentration in environmental samples, was developed in 1984 and appended to the 1983 SAS model document. Two conditions are required to apply this method. First, the source of the contamination cannot be known (i.e. a concentration must be detected in ground water or surface water with no probable waste source identified in the vicinity). Second, the scoring method cannot be combined with any other chemical hazard scoring method. This results in only the environmental resource compartment (ground water, surface water, or air) which contains the contamination being scored.

Finally, an additional 150 points for inherent flammability and reactivity of the known contaminants is also scored in chemical hazard. In order to score these points, however, a fire marshall must declare that an emergency situation exists. This score is based on the National Fire Prevention Association ratings with a correction for waste quantity. As previously noted for the fire and explosion environmental compartment, this scale was applied only once.

After all scores are derived, they are combined according to the following algorithm:

$$\text{Site Score} = \sqrt{GW^2 + SW^2 + AIR^2 + DC^2 + FE^2} \quad + CH$$

where $GW = RP_{gw}\ (\text{Env Exp-}_{gw} + \text{Targets-}_{gw}) + \text{Ex Exp-}_{gw}$

(RP = Release Potential)

(Env Exp = Environmental Exposure)

(Ex Exp = Existing Exposure)

$SW = RP_{sw}\ (\text{Env Exp-}_{sw} + \text{Targets}_{-sw}) + \text{Ex Exp-}_{sw}$

$Air = RP_{air}\ (\text{Env Exp-}_{air} + \text{Targets-}_{air}) + \text{Ex Exp-}_{air}$

$DC = RP_{dc}\ (\text{Env Exp-}_{dc} + \text{Targets-}_{dc}) + \text{Ex Exp-}_{dc}$

$FE = RP_{fe}\ (\text{Env Exp-}_{fe} + \text{Targets-}_{fe}) + \text{Ex Exp-}_{fe}$

and CH = Chemical Hazard.

The compartments are combined as the square root of the sum of the squares of each route scored. This shifts emphasis in the site score toward the maximum compartment score. The chemical hazard maximum score of 450 points is approximately the average of the five environmental resource ($\bar{X} = 454$) and reflects the opinion of the developing committee that it should receive only the potential emphasis of one compartment.

3.6 Other Risk Assessment Models

Numerous risk assessment models have been developed by Federal, State, and local agencies as well as industry or consulting firms. These model systems are loosely arranged in several groups in Table 3.5 for

Table 3.5 Summary of Risk Assessment Models Applied to Environmental Contamination Sites

TYPE/MODEL NAME/REFERENCE	PARAMETERS	NOTES
Simple Perceived Priority Scales		
California Dluglosz and Ingham, 1985	-0,1,2,3 priority -three categories: HRS Score remedy known, cost -no environmental compartment -no Toxicity evaluation	-had developed and abandoned detailed model -sites rated for State funds use
New Hampshire Dupee, 1984	-high, medium, low priority -HRS Sites ranked high -others rated by carcinogenicity and chance of exposure	-rated for State funds expenditure
Connecticut State of Connecticut,	-no hazard, need further evaluation, and imminent hazard priority scales -ground and surface water direct discharge only -no toxicology -rated by incident: PCB, asbestos, pesticides, disposal w/in 200 ft of drinking water supply, fish kills, fire and explosion, discharge to sewer or surface water	-ground water based on LeGrand soil contaminant sorption factor
USEPA Hazard Ranking System (HRS) USEPA, 1984	-detailed model described in text and Figure 3.5 -3 environmental routes: ground and surface water and air -toxicity assessed in routes	-most widely used in country
Variations of HRS		
California Dluglosz and Ingham, 1985	-adds cost/benefit and public health index to HRS -benefit is reduction in HRS score per unit cost of remedy -ground and surface water, air, fire and explosion, and direct contact routes	-abandoned for simple scale above
Wisconsin Wisconsin DNR, 1987	-adds environmental index to HRS score to offset human bias -adds vegetation and wildlife, # endangered species, parkland, unsaturated zone, fisheries, and wetlands	-Environmental index developed from Mi. 83 SAS

Table 3.5 (cont'd.)

TYPE/MODEL NAME	PARAMETERS	NOTES
US Dept. of Energy modified HRS (USDOE mHRS) Napier and Hawley, 1985	-adds radionuclides to toxicity/persistence of HRS -dose related calculations for direct contact or potential exposure based on waste quantity	-adds factors to HRS -score normalized to and 1-100
Little Model Little, 1981	-ground and surface water, air scores normalized to 100, added for maximum site score of 300 -waste reaching pathway has visual proof of contam.	-system never applied
Alternatives to HRS		
System for Prevention, Assessment, and Control of Exposures and Health Effects from Hazardous Sites (SPACE) French, 1984	-4 categories: site characteristics, migration pathway, human exposure, human health -containment, ground and surface water, air, food chain, and soils contact are assessed -water supply system, fish contaminant advisories, and doctor or hospital reports are scored -limited to 5 most toxic contaminants, not greatest quantities toxic contaminants, not greatest quantities	-developed by Federal Centers for Disease Control -human exposure only, no environmental parameters -after calculation of 4 category scores, no algorithm for combination
Remedial Action Priority Priority System (RAPS) Whelan, et al., 1985	-includes radioactive site parameters -also -incorporates submodels to predict transport, transformation, and fate to nearest receptor -calculates exposure concentrations at nearest human and that risk -4 pathways: overland flow, ground and surface waters, air -4 exposures: dermal, ingestion, inhalation, external radiation	-developed by US Dept. of Energy -requires large amounts of data -requires expert interpretation
Hazard Assessment Rating Rating Methodology (HARM) Engineering Science, 1983	-assess migration from military bases to human population -assess whether mitigation reduces migration -2 pathways: ground and surface waters -receptors, waste characteristics and migration potential (site flooding and and migration time) -adequacy of state of art waste management is assessed -toxicology based on safe levels of contaminants, even carcinogen -summed to produce site score	-developed by US Air Force Force -appears designed to justify "no action" alternative -ranks for further evaluation -does not use site monitoring data automatic low score if contamination is confined to base

Table 3.5 (cont'd.)

TYPE/MODEL NAME	PARAMETERS	NOTES
HARM II Barnthouse et al., 1986	-basic structure that of HARM -uses monitoring data -ranks sites for RI/FS after site studies -after contamination leaves base, quality/value receiving environment is assessed	benefit term must be substantial from remediation or score is reduced -if environment is contaminated, score reduced
Confirmation Study Ranking System (CSRS) Luecker, 1982	-waste characteristics rated 1 to 3 for quantity acute and chronic toxicity, persistence, reactivity, flammability, physical state -waste sets state of art as standard and does not have have term for containment failure	-developed by US Navy -variation of HARM -site score normalized to scale of 0 to 1
Prioritization of Environmental Risks and Control Options (PERCO) Little, 1983	2 part model: chronic and episodic hazards -4 chronic: air, ground and surface waters, soil & direct contact 4 episodic: acute exposure, fire and explosion, toxic vapors, floods -3 optional: recreation, fishing, and ecological impact scores health effects threshold -distance/density evaluation of population at risk	-developed for Massachusetts by consultant -used to allocate state remedial funds -requires specific data -subjective
New Jersey Severity Index Kloo, 1986	-product of waste characteristics and exposure potential scores -waste characteristics: toxicity, persistence,quantity, containment adequacy -exposure: ground and surface waters, air, soil, fire and explosion, direct contact, population density, sensitive environments	-screening index, used to to rank sites for inspection -score normalized to 0 to 100 -observed contamination defaults to maximum score, bypasses potential exposure
Human Exposure Potential Ranking Model (HEPRM) Life Sciences, Inc., 1986	-4 factors: chemical and target characteristics release probability, size and proximity of population -40 exposure pathways such as: drinking contaminated ground or surface waters, swimming, inhalation of contaminated ground water while washing, soil ingestion, etc. -toxicity assessed by Sax criteria	-developed for New York by consultant -prioritize sites for investigation and remediation -based only on human health -many calculations, labor intensive

Table 3.5 (cont'd.)

TYPE/MODEL NAME	PARAMETERS	NOTES
Hazard Assessment of Landfill Operations (HALO) Her Majesty's Inspectorate of Pollution, 1988; Gerrard, pers. com.	-considers waste quantity and migration -7 components: waste pollution potential, landfill operations assessment, ground and surface waters, landfill gas direct contact, local amenity considers public attitude -subsurface gas migration is major parameter	-English model -does not consider toxicology -component scores normalized not combined -scored from questionnaires to landfill operators, local officials
<u>One Compartment Models</u>		
LeGrand LeGrand, 1964, 1980	-assesses aquifer vulnerability -considers: distance between contamination source and ground water, depth to water table, water table gradient, permeability/sorption of soil, contaminant severity -includes confidence in data factor and reliability of information	-basis for many other models ground water scoring -nature and permeability of soils overlying aquifer is source for other models
DRASTIC USEPA, 1985	-not ranking model -used to predict ground water contamination -7 factors: depth to water, net recharge, aquifer medium, soil medium, land topography, hydraulic conductivity -factors multiplied by weights reflecting importance	-expands on LeGrand -summed for final index -still in testing, being adapted for use in RCRA
Illinois Rating Scheme (IRS) Gibb, et al., 1983	-ground water contamination -4 factors: waste health risk and handling method,population at risk, waste proximity to aquifer in use, aquifer susceptibility	-screening tool for human health threat -score normalized to 0 to 100
Monroe County New York Methodology (MCM)	-6 ground water categories: identifiable (known source and contamination, possible (apparent-release), suspicious (no visible evidence but poor management), unspecified (known contamination, unknown source), lagoons, auto junkyards, salvage areas -factors: overburden geology, permeability, land relief/geomorphology, depth to aquifer, bedrock characteristics, soil properties, land use, -site activity/history/waste classification record compiled	-rank sites for evaluation -default for sites near public water supply wells -priority decision subjectively based on score and site activity record

Table 3.5 (cont'd.)

TYPE/MODEL NAME	PARAMETERS	NOTES
Comprehensive Environmental Response, Compensation, and Liabilities Act Reportable Quantities (CERCLA RQ) USEPA, 1983, 1985 Environmental Monitoring Services, 1985	-used to determine quantities of chemical releases which must be reported under Section 102 of CERCLA --calculates severity scores for reactivity, ignitability, acute, chronic, and aquatic toxicity -3 exposure routes: ingestion, inhalation, dermal -persistence adjustment based on biodegradation, hydrolysis, photolysis	-severity index rated 1 to 100 -Reportable quantity threshold of 1, 10, 100, 1000, or 5000 kg depending on severity index -carcinogenicity not included
Clement Clement Associtaes, Inc., 1981	-rates 32 chemicals by relative risk to human populations per unit dose -factors: carcinogenicity, teratogenicity, reproductive toxicity, mutagenicity, hepatogenicity -scorer calculates unit exposure dose	-requires acceptance of of carcinogenicity threshold -toxicology expertise required
Quantitative Structure Activity Relationships Johnson, et al., 1983	-data base of acute and chronic toxicity, carcinogenicity, physical characteristics -can predict these values from organic chemical formulae and known structure activity relationships for other chemicals	-used for some chemicals in Appendix A of Appendix A
Resource Conservation and and Recovery Act Hazardous Waste Streams Model (RCRA HWSM) Environ Corp., 1985	-evaluates RCRA listed waste for land disposal prohibition -rates acute and chronic toxicity in range 1 to 10 -chronic toxicity rated by Equivalent Dose Estimate (EDE) -assigns EDE by structure activity relationships when insufficient data	-proposed, not promulgated -EDE raised or lowered by 1 point depending on acute toxicity value
<u>Special Interest Systems</u>		
Liner Location Risk and and Cost Analysis Model (LLRCAM)	-examines performance and cost effectiveness of management systems -assesses landfill liner performance per unit cost -comparison to alternative land disposal	-developed for policy analysis -not site specific

Table 3.5 (cont'd.)

TYPE/MODEL NAME	PARAMETERS	NOTES
RCRA Risk-Cost Analysis (WET) ICF, 1984 Males, 1984	-evaluates different management practices for waste streams regulated by RCRA	-developed for policy analysis -not site specific
National Oceanographic and and Atmospheric Administration System NOAA, 1984	-assesses risk of imminent harm -applied after site discovery and declared a site in Superfund -3 parameters: waste proximity to humans, value of threatened environment, chemical properties and toxicity	-assess sites under agency responsibility -sites not ranked
Impact Scoring Methodology (ISM) TVA and ORNL, 1983	-designed to assess mine waste -large volume, low toxicity waste -includes physical impact such as land stripping	-ignores landfills on mine lands

comparison: simple perceived priority scales, the USEPA Hazard Ranking System (HRS) and its modifications or derivations, alternatives to the HRS, one compartment or specific resource systems, and special interest systems. All of these models are structured value systems based upon the needs of the model developer. Probabalistic models have also been developed but these are restricted to strict health hazard or chemical hazard systems which are summarized in the special interest systems section. The intent, highlights, and applications of many of these models are presented in the table.

One compartment models usually consider ground water contamination risk to the exclusion of other media. A few of the models assess the sorption characteristics of soils: a factor considered in the migration potential prediction parameter in the model proposed in this paper. One aquifer vulnerability model, the LeGrand model (LeGrand, 1964, 1980) forms the basis for most of the ground water assessment pathways of the various contamination site models, including the 1983 SAS. Originally designed to assess aquifer vulnerability at waste disposal sites, the LeGrand system is not a ranking system. The concept and parameters assessing the nature and permeability of the soils overlying the aquifer are included in virtually every other contamination site model with the notable exception of the HRS.

The chemical hazard model is another type of one compartment model. These are not site ranking models but are applied to assess the chemical characteristics and toxicity of chemicals. Several of these models were reviewed for ideas to improve the chemical hazard portion of the 1983

SAS. The common point of these chemical models is their ability to assess and reduce to common terms a variety of toxicity parameters in addition to acute toxicity. This demonstrates that chemical hazard evaluation can be based on criteria other than the simple criteria applied in the HRS and that different parameters can be combined to derive an overall toxicity value. Factor scores are derived instead of a probabilistic function. The structure activity relationships methods allow evaluation and scoring of contaminants which would otherwise be ignored due to a lack of sufficient data.

The local amenity component of HALO considers public attitudes about a facility, something no other reviewed model does. Industrial and sanitary waste are codisposed in England instead of being placed in separate facilities (Gerrard, 1990) indicating that any facility could be hazardous. Without response legislation, however, rankings would only identify the worst sites without doing anything toward management or mitigation. The information collection method, questionnaires to landfill operators, local waste and health officials, and other selected sources, could reduce the problem of scoring a facility with insufficient data or comparing facilities with different levels of information.

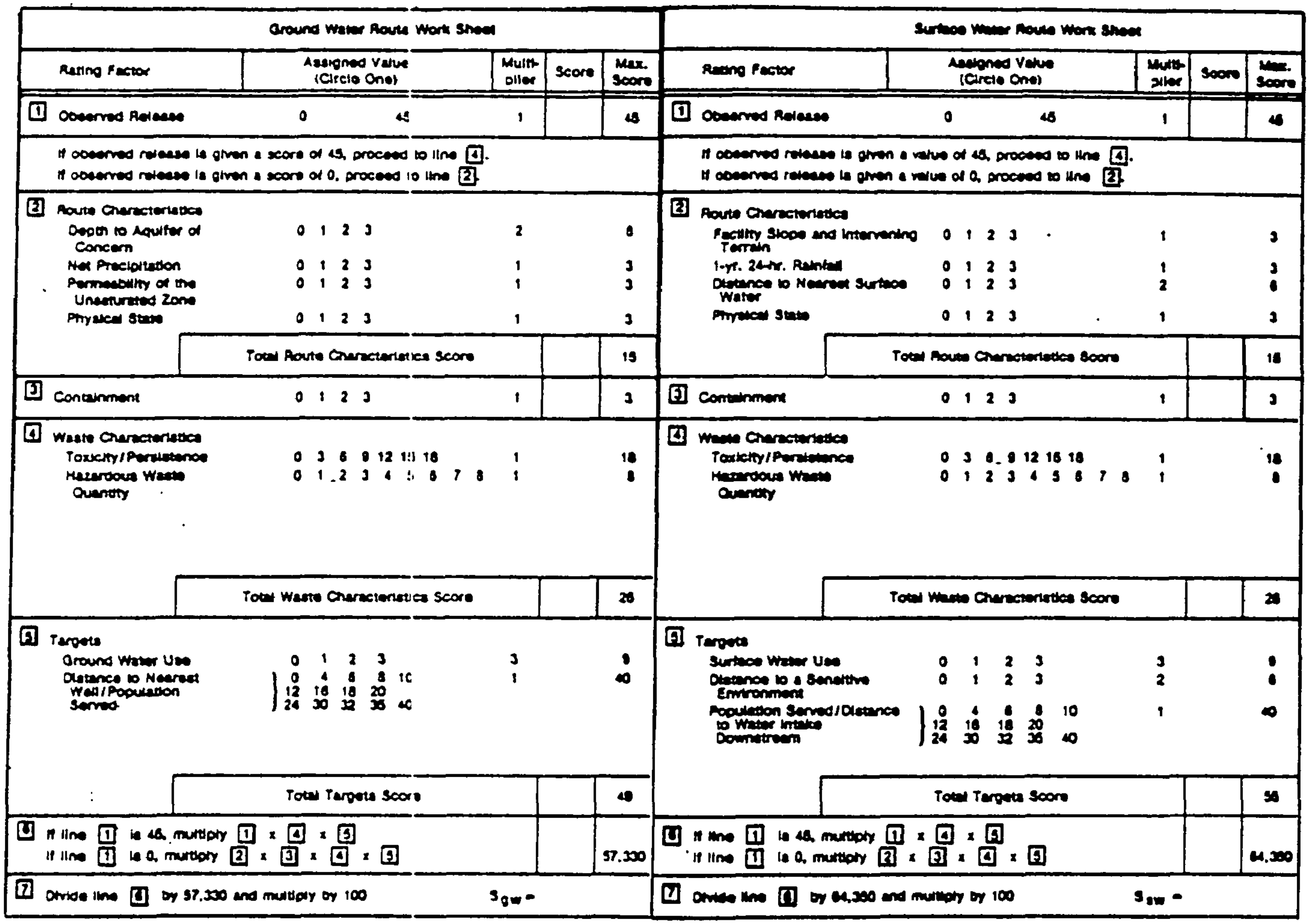
3.6.1 USEPA Hazard Ranking System

The Hazard Ranking System, (HRS) (USEPA, 1984) is the most widely used risk assessment model in the country by virtue of its application in the Federal Superfund program. This model will be described in greater detail than other models in Table 3.5 because of its broad application and the need to decide whether this model should be adopted in Michigan rather than modifying the SAS.

The basic layout of the HRS is presented in Figure 3.5. This model evaluates three environmental resource pathways or routes, ground water, surface water, and air. Mathematically, the HRS multiplies the parameters within each environmental exposure route, divides by a maximum score different for each route, combines the route scores by the root mean square method, and normalizes the final site score to a scale of 100.

The HRS employs an exclusive approach to observed release (existing exposure) and potential release (potential exposure) by requiring one or the other to be scored in each environmental compartment. An observed release is scored when environmental samples reveal contamination in ground water, surface water, or air. Absent proof of contamination, migration potential to targets within each route is assessed.

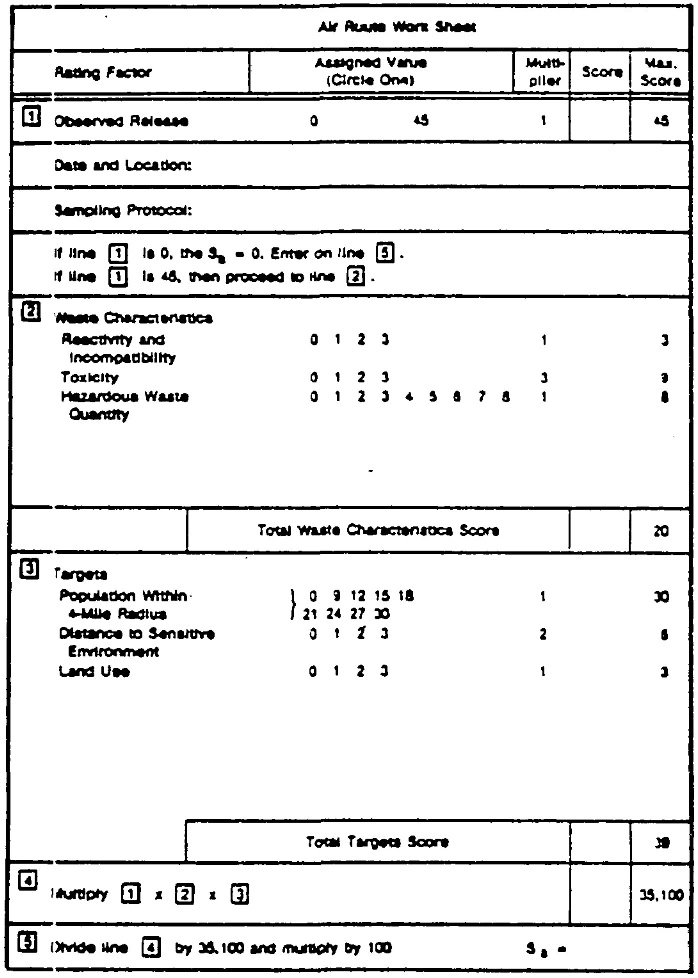
Chemical hazard is assessed in each environmental compartment as a function of toxicity and persistence but not in terms of routes of exposure within each compartment. Toxicity is based upon Sax toxicity ratings (Sax, 1975) which are scaled on a 1-3 basis. The idea of using a toxicity rating rather than toxicity probability is similar in concept to the Michigan method of potential toxicity scores. The Sax system is heavily skewed in terms of acute toxicity and does not include mutagenicity, teratogenicity, or bioconcentration. Some consideration



Ground Water Route Work Sheet				
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score
$\boxed{1}$ Observed Release	0 45	1		45
If observed release is given a score of 45, proceed to line $\boxed{4}$. If observed release is given a score of 0, proceed to line $\boxed{2}$.				
$\boxed{2}$ Route Characteristics				
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
$\boxed{3}$ Containment	0 1 2 3	1		3
$\boxed{4}$ Waste Characteristics				
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
$\boxed{5}$ Targets				
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
$\boxed{6}$ If line $\boxed{1}$ is 45, multiply $\boxed{1}$ x $\boxed{4}$ x $\boxed{5}$ If line $\boxed{1}$ is 0, multiply $\boxed{2}$ x $\boxed{3}$ x $\boxed{4}$ x $\boxed{5}$				57,330
$\boxed{7}$ Divide line $\boxed{6}$ by 57,330 and multiply by 100	S_{gw} =			

Surface Water Route Work Sheet				
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score
$\boxed{1}$ Observed Release	0 45	1		45
If observed release is given a value of 45, proceed to line $\boxed{4}$. If observed release is given a value of 0, proceed to line $\boxed{2}$.				
$\boxed{2}$ Route Characteristics				
Facility Slope and Intervening Terrain	0 1 2 3	1		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
$\boxed{3}$ Containment	0 1 2 3	1		3
$\boxed{4}$ Waste Characteristics				
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
$\boxed{5}$ Targets				
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
$\boxed{6}$ If line $\boxed{1}$ is 45, multiply $\boxed{1}$ x $\boxed{4}$ x $\boxed{5}$ If line $\boxed{1}$ is 0, multiply $\boxed{2}$ x $\boxed{3}$ x $\boxed{4}$ x $\boxed{5}$				64,350
$\boxed{7}$ Divide line $\boxed{6}$ by 64,350 and multiply by 100	S_{sw} =			

Figure 3.5 Schematic Diagram of the USEPA Hazard Ranking System (Taken from USEPA, 1984)



Air Route Work Sheet

Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score
$\boxed{1}$ Observed Release	0 45	1		45
Date and Location:				
Sampling Protocol:				
If line $\boxed{1}$ is 0, the S_a = 0. Enter on line $\boxed{5}$. If line $\boxed{1}$ is 45, then proceed to line $\boxed{2}$.				
$\boxed{2}$ Waste Characteristics				
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
$\boxed{3}$ Targets				
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
$\boxed{4}$ Multiply $\boxed{1}$ x $\boxed{2}$ x $\boxed{3}$				35,100
$\boxed{5}$ Divide line $\boxed{4}$ by 35,100 and multiply by 100		S_a =		

Figure 3.5 (con't.)

is given to chronic and carcinogenic toxicity, although much less than in the potential toxicity scores of the 83 SAS. The same toxicity rating is given to each contaminant in all three environmental compartments, ignoring routes of exposure specific to the compartment. For example, the Sax criteria are principally based upon ingestion toxicity which is adequate for drinking water evaluations but is inappropriate for the air compartment where inhalation routes of exposure should be considered. Similarly, dermal absorption should also be involved in evaluations for the surface water route due to the potential for exposure while bathing or swimming. This exposure should be considered in addition to ingestion of potable water from surface water intakes.

In the targets portion of the HRS, few parameters are scored in any of the exposure routes. In the ground water route, the unsaturated zone is not scored while the saturated zone score is derived for the aquifer of concern, the aquifer which is the principal drinking water source. Overlying aquifers are ignored if they are not used for drinking water. The population at risk in the ground water route scores not only the total population which uses the aquifer, but the distance to the nearest well. In the surface water route, the migration parameters of distance to surface water and slope of the intervening land between the waste source and the surface water body are scored. Only human populations are given any significance in scoring although distance to sensitive environments, including wetlands, is assessed. Some consideration is given to human recreational or irrigation use of the surface water body in the population at risk scoring but no consideration is given to fisheries or basic surface water value. In the air compartment, only human populations are scored and no consideration is given to mobility of contaminants adsorbed onto soil particles.

Direct contact and fire and explosion compartments are scored but the results are not considered in a total site score. These parameters are considered separately by the agency when making a decision to undertake an emergency response at a site. The reasoning is that contaminants which pose these hazards should receive immediate response and not wait several years for inclusion on the National Priorities List before cleanup or control/mitigation. Interestingly, during revision of the HRS (yet to be promulgated) (USEPA, 1988), the USEPA examined the inclusion of direct contact hazard and fire and explosion in the overall site score by the 1983 SAS and decided to incorporate direct contact as an on-site exposure route. In the Revised Site Assessment System developed in this study, the direct contact and fire and explosion categories in the 1983 SAS are considered as emergency or immediate response criteria and not part of the basic site scoring system.

3.6.2 Factors in Common

Most models are heavily, often exclusively, biased toward human populations with little consideration of the environment. Certain factors recur in many of the risk assessment models. Three contamination pathways, ground water, surface water, and air, are assessed with a direct contact pathway sometimes added. If a model is a one compartment model, it generally considers only ground water. Some of the one compartment models considered only waste characteristics and toxicity, however. Most of the models assess observed and potential release but in an exclusive fashion, if one is scored, the other is not. Within each pathway, migration potential is evaluated only in terms of physical state. No consideration is given to interaction of contaminants with environmental media once a waste escapes containment. The nature of the overlying soils or unsaturated zone, distance to surface water, site slope, adequacy of containment, and soil or gas phase mobility are repeatedly considered in exposure potential. In targets, human population at risk, aquifer quality, and sensitive habitats are usually scored.

Contaminant toxicity is most often scored within each pathway when there are multiple pathways but independently evaluated if there are only one or two compartments. However, when evaluated within each environmental pathway, toxicity is seldom based on exposure routes valid only for that pathway: toxicity is assesed only once for each site and the toxicity assessment is repeated from pathway to pathway. Toxicity evaluation is often based on acute toxicity with simple, low discrimination, rating scales.

Within pathways, the methods of mathematical score combination fall equally into two groups, addition or multiplication of parameters. The most common method of pathway combination is by root mean square with one third of the models normalizing the final site score to a scale of 100.

4.0 Model Revision

4.1 Model Problems and Revisions

In 1987, a public committee, chaired by the author, was convened by the MDNR to review and make recommendations for changes to the 1983 SAS model. The committee, reviewed the model and a staff report on model problems (Carpenter, 1988b) and made several recommendations to the MDNR (SASCOM, 1988) concerning the model design and its application. The major problems and the resulting revisions made to the model are presented in the text below.

While numerous detailed model changes have been made, only the major structural or technical changes and their rationale are discussed in this chapter. The entire scoring model is presented as a practical guidance document with worksheets in Appendix A.

4.1.1 Model Structure

A two-tiered model structure consisting of a screening system to identify the more severe sites followed by a more detailed evaluation or scoring of those sites is called for in Michigan. There are more than 2600 sites in the State and there is not enough time or staff available to score them all with a detailed ranking model. By examining all sites with a screening system first, detailed scoring efforts with limited resources can concentrate on sites which need more immediate attention and postpone evaluation of sites which will not be responded to until later. Application of a screening tier also helps to identify site data gaps and avoids expenditure of scoring effort which could lead to incorrectly defining a site as of low risk (the false negative).

4.1.1.1 Overview of Revised Screening System Organization

1983 Screening System Inadequacies

Sites qualify for detailed SAS scoring by equalling or exceeding a threshold score in the 1983 screen which indicates that the site should be identified among the sites needing first response with state funds. As previously seen in Figure 3.2, two major weaknesses are evident in the screening model. First, there is an over emphasis on existing exposure and factors related to waste quantity and toxicity relative to other factors in the screening model. Second, there is an inadequate evaluation of contaminant toxicity and quantity with insufficient discrimination among contaminant type or hazard. A further weakness is that the model inadequately assesses the potential for future or further contamination. Often, if existing exposure was not known, a site did not qualify for detailed SAS scoring even though there may be a potential for extensive contamination at the site. The basic problem is that the screening model does not reflect the logic of the detailed scoring model and thus is a poor predictor of hazard as assessed by that model.

The screening system has been extensively revised and is detailed in Appendix A. An extensive discussion of the screening system will not be presented in this chapter because most of the principles and rationale derive from the revised SAS. The structure and major changes in the RSAS are extensively discussed later in this chapter.

Figure 4.1 shows the proposed organization of the new screening system. The nine factors in the 1983 system have been reduced to five categories while the range of points and discrimination within the categories have been expanded. Existing exposure and known environmental contamination have been consolidated into known environmental contamination, while the potential environmental contamination category has been added. Contaminated soils have been added as a factor in the known environmental exposure category. A sensitive environment category has been added as has a factor for schools, hospitals or nursing homes within the population category. The direct contact hazard and the fire/explosion hazard in the 1983 system have been dropped from the screening system because these factors are more appropriate to an emergency response decision process.

Finally, the chemical concern, volume of chemicals, and liquids factors in the 1983 screening system have been consolidated into the toxicity/quantity concern category. This category has been greatly improved by considering the hazard of contaminants on site as well as their quantity. A subcategory which considers waste type characterization when contaminant identification and quantification have not been done for a site, will help to avoid the possibility of a false negative determination (failure of a potentially severe site to attain the screening system threshold and qualify for detailed scoring because

Environmental Contamination

Medium	Potential Contamination	Known Release	Environmental Impact	Human Exposure	
Soils	2	4	6	8	
Ground Water	2	4	6	8	
Surface Water	2	4	6	8	Max 20pts
Air	2	4	6	8	

Contaminant Mobility

Moderately Mobile	Mobile
3	6

Sensitive Environment Within One-Half Mile 3

Population At Risk

Density per square mile	Points
Less than 100	0
100 - 500	1
500 - 2500	3
More than 2500	5

School, Hospital or Nursing Home Within One-Half Mile 1

Contaminant Concern

Concentration (ppb)	Quantity (kg)	Potential Toxicity Score 5-9	10-14	15-19	20-29	≥30
1 - 100	<25	1	3	5	7	9
101 - 1000	25-1250	3	5	7	9	11
1001 - 10000	1251 - 5000	5	7	9	11	13
> 10000	>5000	7	9	11	13	15

or

Acres	Cubic Meters	Waste Type Characterization E	D (5)	C (10)	B (15)	A (20)
<.5	<250	1	3	5	7	9
.5-10	251 0 5000	3	5	7	9	11
11 - 20	5000 - 10000	5	7	9	11	13
>20	>10000	7	9	11	13	15

Maximum Possible Points = 50

Figure 4.1 Schematic Diagram of the Revised Screening System of insufficient data). This structure parallels the chemical hazard scoring options in the detailed model.

4.1.1.2 Overview of Revised Detailed Scoring System Organization

The Revised SAS model has undergone considerable physical and technical change while retaining the basic philosophy and structure of the 1983 model. The system organization is shown in Figure 4.2 which is used as the site score sheet where all points assigned to the various model components are recorded and totaled. Changes in the model outlined below are discussed in the following subchapters.

One notable revision is the removal of the direct contact and fire and explosion routes from a direct calculation of site score. These factors have been removed from the site ranking model because they are more appropriate for inclusion in decisions for emergency response, as is done in the HRS. This was decided because, unless included in emergency response, significant direct contact hazard could be allowed to continue and perhaps worsen. It was reasoned that if private water supply wells and public water supply systems were replaced with emergency funds simply because a known exposure was occurring, the same immediate mitigation of direct contact and fire/explosion should occur.

Also removed from the 1983 model is the flammability/reactivity portion of the chemical hazard category (an element which was redundant with the fire and explosion route). The removal of fire and explosion and flammability/reactivity is also justified by the discovery, during a

	AIR		GROUNDWATER		SURFACE WATER	
	RATING FACTOR (Range of Scores)	SITE SCORE	RATING FACTOR (Range of Scores)	SITE SCORE	RATING FACTOR (Range of Scores)	SITE SCORE
	Release Potential (1.0-2.0)		Release Potential (1.0-2.0)		Release Potential (1.0-2.0)	
	Environmental Fate (0.25-2.0)		Environmental Fate (0.4-2.0)		Environmental Fate (0.4-2.0)	
POTENTIAL EXPOSURE	Mobility (0-50)		Overlying Soils (0-100)		Distance to Surface Water (0-20)	
					Site Slope (0-20)	
					Flood Potential (0-10)	
					Fish Ingestion (0-50)	
	Site Activity (0-25)		Useable Aquifer (0-100)		Lake (0-15)	
					Stream (0-10)	
					Wetland (0-15)	
					Cold Water Fishery (0-10)	
	Population At Risk (0-100)		Population At Risk (0-100)		Population At Risk Drinking (0-100)	
					Population At Risk Bathing (0-50)	
	POTENTIAL EXPOSURE SCORE (PE)		POTENTIAL EXPOSURE SCORE (PE)		POTENTIAL EXPOSURE SCORE (PE)	
EXISTING EXPOSURE	On-Site Concentration (0-250)		Wells Monitoring (0-125)		Environmental Exposure (0-50)	
	Off-Site Concentration (0-150)		Wells: Drinking Water (0-250)		Populations: Drinking Water (0-250)	
	Soil Deposition (0-150)		Wells: Irrigation/Livestock (0-50)		Fish Advisory (0-50)	
					Water Supply: Irrigation/Livestock (0-50)	
	EXISTING EXPOSURE SCORE (EE)		EXISTING EXPOSURE SCORE (EE)		EXISTING EXPOSURE SCORE (EE)	
	COMPARTMENT SCORE (PE + EE)		COMPARTMENT SCORE (PE + EE)		COMPARTMENT SCORE (PE + EE)	

CHEMICAL HAZARD (0 - 1300)	
	TOTAL SITE SCORE

Figure 4.2 Schematic Diagram of the Revised Site Assessment System (RSAS)

review of the factors driving the model, that these elements were scored for only a few sites and did not impact the final site score or rank. Direct contact was more frequently scored and contributed to the site score and rank of several sites but the score for this element was usually reduced within a year of first scoring due to interim response.

The release potential factor has been augmented by an environmental fate factor and renamed migration potential. The parameter improves the prediction of the probability of contaminant migration once it has escaped its containment.

For the population at risk score, the zones of concern have been altered in both the ground water and surface water compartments depending on the direction of ground water flow or whether the potentially contaminated water body is a stream or lake. The surface water population at risk has also been altered to differentiate drinking water contamination from potential recreational bathing and fishing exposures.

The air compartment, which seldom had any impact on site scores using the 1983 model, has been restructured to include elements from the former direct contact route. In addition, the thickness of contaminated soils available for volatilization of contaminants and wind dispersion has been increased from one-half to six inches.

In the ground water compartment, the saturated and unsaturated zones tables have been renamed useable aquifer and overlying soils, respectively. These parameters have been refined and their score distributions have also been altered.

In The surface water compartment, wetlands and fisheries values have changed while factors for lakes and streams have been added.

Finally, the chemical hazard portion of the model has been completely revised. Reevaluation of the relationship between waste quantity, the potential toxicity factor, and the chemical hazard score resulted in an equation describing that relationship. The equation replaces several tables and figures in the 1983 SAS and greatly simplifies chemical hazard scoring. A hierarchy of alternatives for deciding which contaminant identification and quantification methods should be used has been provided. The table for waste type characterization has been expanded and definitions of waste categories, which correlate better with the types of waste most likely to be found at a site, have been developed. Assignment of a potential toxicity factor to the waste categories also allows use of the equation for the waste characterization chemical hazard scoring method. The chemical hazard score has been increased from 450 points in the 1983 SAS to 1,300 points in the revised SAS. An individual contaminant, however, is limited to 1,000 points.

The overall score maximum has increased from 2000 in the 1983 model to 2888 in the 1988 model. It was not possible to derive a simple maximum score (such as 3000) without distorting the balance of compartment scores and overemphasizing a particular compartment. As in the 1983 model, the scores for the three exposure compartments are still combined by taking the square root of the sum of the compartment squares. The resulting value is then added to the score from the chemical hazard portion of the model to produce the site score.

4.1.2 Contaminant Characterization And Quantification

Site hazard evaluation depends on adequate identification and quantification of wastes discarded at the site. In the 1983 SAS, calculation of the waste characterization and quantification data was conducted in two different ways in two sections of the model scoring process, release potential and chemical hazard assessment. In the revised model, instead of calculating waste quantity in different portions of the scoring process, the calculations are done as the first step of the process and the data transferred to the chemical hazard and migration potential sections.

Selection of the waste quantification method should be done according to the following hierarchy: 1) known source, contaminants and quantities or calculated quantities, 2) known source, waste characterization and containment size, and 3) unknown source but known contaminants and concentrations. While scoring a site, the highest level in the hierarchy should be used, but a site may require using more than one method depending upon the amount of information known about the various containment structures on site. If the identity and quantity of contaminants are known or the quantity has been calculated, this information should be used in site scoring. Waste type characterization and quantity estimates may be used if there is good reason to suspect that there are other, additional contaminants at the site or that the waste quantity is underestimated so that use of direct evidence would result in a unrepresentative low score. The procedures for the various waste quantity calculation methods are presented in the waste quantification portion of the full model in Appendix A.

Unknown contaminants are addressed by characterization of the waste according to its generation source using Table 4.1 and the containment size is used to derive the level of concern score in the chemical hazard section (Chapter 4.1.3). A relative hazard or level of concern has been assigned for the wastes associated with the various generator categories.

The unknown source but known contaminants and concentrations method generally can only be applied for the affected compartment i.e. ground water for a contaminated drinking water well or surface water for contaminated sediments. In some cases, however, more than one compartment may be scored. For example where a contaminated ground water seep is flowing into a surface water body, both the surface water and the air (if the contaminants were volatile) compartments could be scored.

4.1.3 Chemical Hazard Compartment Revision

The chemical hazard category assesses the inherent toxicity of the contaminants identified at a site and determines the potential for

Table 4.1 Revised Model Waste Characterization Categories

Level of Concern	Description and Examples	
20	CLASS A (Highest Hazard Potential)	
	Operations producing large amounts of chemical or industrial wastes or products, heavy manufacturing	
	Pharmaceutical Production	Agricultural Chemicals
	Bulk Warehouses	Organic Chemical Prod.
	Explosives	Dyes and Pigments
	Wood Treatment	Chemical Formulation
	Plating Shops	Heavy Metals Prod.
	Printed Circuits	Monomer Synthesis
	Polymer Synthesis	Chemical Treating
	Chemical Coating	Chemical Bonding
	Oil Paint Prod.	Large Assembly Plants
15	CLASS B (Secondary Hazard Potential)	
	Operations producing moderate amounts of chemical or industrial wastes or products, light manufacturing	
	Primary Metals Production	Rubber Products Prod.
	Small Assembly Plants	Battery Production
	Inorganic Chemical Production (non-heavy metals)	
	Sealant Production	Clay/Glass Production
	Bodywork and Paint Shops	Soap and Detergent Prod.
	Pulp and Paper Production (chlorine bleaching)	
10	CLASS C (Moderate Hazard Potential)	
	Operations with low chemical use and disposal needs	
	Product Assembly	Plastics Fabrication
	Plastics Molding	Metal Stamping
	Machining	Auto Repair (non paint)
	Aircraft Assembly	Boat Assembly
	Latex Paint Production	Medical/Hospital Wastes
	Pharmaceutical Formulation	Soap and Detergent Form.
	Laboratory Waste	Consumer Packaging
	Cleaning Transport Vehicles	
	Pulp and Paper Production (no chlorine bleaching)	
	Coal Ash or Foundry Sands (EP Toxic, hazardous)	
5	CLASS D (Low Hazard Potential)	
	Operations producing or disposing of domestic or commercial wastes in household level quantities	
	Coal Ash or Foundry Sand (non EP Toxic, non hazardous)	
0	CLASS E (Wastes Regarded As Inert)	
	Wastes defined as inert by Act 641 of the Public Acts of 1978 or its rules	

adverse human health and environmental effects upon exposure. The system considers chemical characteristics and quantity together to define the level of concern associated with the chemicals present at a particular site.

4.1.3.1 CMR Revision

The MDNR, via a public committee, has revised the Critical Materials Register (CMR) Criteria which form the basis for the potential toxicity factors used in chemical hazard scoring (MDNR, 1988). The specific CMR criteria used to develop the potential toxicity factors include carcinogenicity, mutagenicity, reproductive/developmental toxicity, other toxicity (including subacute, subchronic, chronic toxicity to terrestrial and aquatic animals, and phytotoxicity), bioaccumulation, tainting/aesthetic properties, and environmental fate (persistence). Acute toxicity may be considered for scoring only if there is a lack of adequate toxicity data on a contaminant to predict its low level, long term exposure effects. Otherwise, acute toxicity and the high hazard physical/chemical properties of flammability, reactivity, and corrosivity are considered more appropriate in evaluating emergency response. Potential toxicity factors have been derived for many contaminants and are listed in Appendix A to the scoring manual in Appendix A.

4.1.3.2 De Minimus, De Maximus

There is some point below which impact may not be observable or attributable to a contaminant present. There is considerable disagreement where this no observable effect level lies for most contaminants: indeed, it is often argued by environmentalists that there is no threshold while industry claims no effect, sometimes up to very high concentrations. For example, at a hearing concerning a contamination site involving 1,4-dioxane, a suspect carcinogen, a member of the public alleged that it is a known carcinogen at 0.5 ppb while a responsible party consultant deemphasized carcinogenicity, calling it a promoter rather than an inducer (MDNR, 1989). In a separate publication (Hartung, 1989), the consultant admitted carcinogenicity in rats at 0.5-1% concentrations in drinking water. He also asserted minor liver and kidney damage at a reference dose of 3.4 mg/kg and an aquatic toxicity concentration of 163 ppm.

While there is considerable disagreement in the effective quantity of a contaminant which may elicit a response, it is clear that some limiting level is needed. Although somewhat arbitrary, there is a point beyond which increasing hazard is negligible. The maximum score obtainable for each contaminant is therefore set at 1,000 points. It was also determined that a single contaminant should not be able to obtain the maximum chemical hazard score and that other contaminants should be able to contribute to the chemical hazard score. The maximum chemical hazard score for all contaminants on site was therefore set at 1,300 points, a level approximately equal though somewhat less, to the maximum score which could be obtained in the environmental compartments.

A de maximus quantity of a single contaminant at a site is set at 100,000 kg. There are sites (Cannalton Industries and G and H Landfill, Appendix B) where the waste quantity greatly exceeds 100,000 kg. These sites are assessed as significant, obtaining the 1,300 de maximus chemical hazard score. An increase in maximum waste quantity by another log cycle (from 1 x 10^5 to 1 x 10^6) without increasing the score ceiling would reduce score discrimination in the lower waste quantity ranges where discrimination is needed. Conversely, an increase in the individual contaminant score limit would have to be large in order to have an impact on the total site score and this would overemphasize the chemical hazard compartment relative to the environmental compartments.

A value of 1 kg of known contaminant as a de minimus level was derived through back estimation from the maximum quantity of contaminant predicted for a site. Five log cycles down from 100,000 kg, 1 kg would result if the common analytical detection limit of 1 ug/liter (or 1 ug/kg) is observed in 1 x 10^9 liters (or 1 x 10^3 m^3) in an environmental sample. In terms of total identified contaminant quantity, this is a small value. However, lesser quantities could be difficult to reliably detect as could attribution of impact.

4.1.3.3 Scoring Chemical Hazard

In the 1983 SAS, it is easier to score a site by waste characterization than by known contaminant quantity simply because only a rough estimate of the site or area of contamination is needed. It is also easier to get a high score in the characterization method than it is in the known quantity method because of the latitude in characterization of the severity of the waste, the ease of over-estimating the area of waste, and a poor relationship between the characterization and known quantity methods.

Chemical hazard scoring in the 1983 SAS is very complicated and requires numerous steps. To score more than one known contaminant at a site, one has to recalculate the pure quantity of each contaminant, look up the potential toxicity score for each contaminant, group the contaminants in four potential toxicity score ranges (1-10, 11-20, 21-40, >40), total the quantity of waste in each range, derive a level of concern score for the total quantity in each range, and add the level of concern scores to derive a final known contaminant level of concern score. This requires the use of four forms and a score chart (Figure 3.3). The score chart is also limited in the degree of discrimination it provides because only seven to ten point values up to 450 points are available within each potential toxicity score range (Figure 3.3) This process tends to cause chemical hazard scores to clump (Gruben, 1989) which further reduces discrimination among site scores.

In the revised model, the known contaminant scoring method has been simplified to a few steps, one form and the use of an equation for derivation of a chemical hazard score for each contaminant. The equation was derived once the relationship between waste quantity, potential toxicity factor, and chemical hazard score was established.

As shown in Figure 4.3, when the waste quantity is held constant, chemical hazard is considered a function of the potential toxicity factor. It varies as a linear function of the potential toxicity factor and equals it at the de minimus quantity of one kg of identified contaminant. Chemical hazard is also a function of waste quantity and, when the potential toxicity factor is held constant, appears as a logarithmic function as shown in Figure 4.4.

This interactive relationship is shown in Figure 4.5 where the chemical hazard score for some selected potential toxicity factors varies logarithmically with the logarithm of waste quantity. The median potential toxicity factor of the contaminants in Appendix A to the revised model (Appendix A) was found to be 12. After rounding down to a potential toxicity factor of 10, the intercept, where chemical hazard equals the potential toxicity factor at the de minimus quantity of one kg, was set at ten. The slope of the line was determined by completing the potential toxicity factor line between the maximum individual chemical hazard score of 1,000 points and the intercept. Using the least-squares regression method of best fit to the relationships shown in Figure 4.5, and the variables expresssed as logarithms, the slope of the lines is calculated to be 0.5. This slope function, chemical hazard

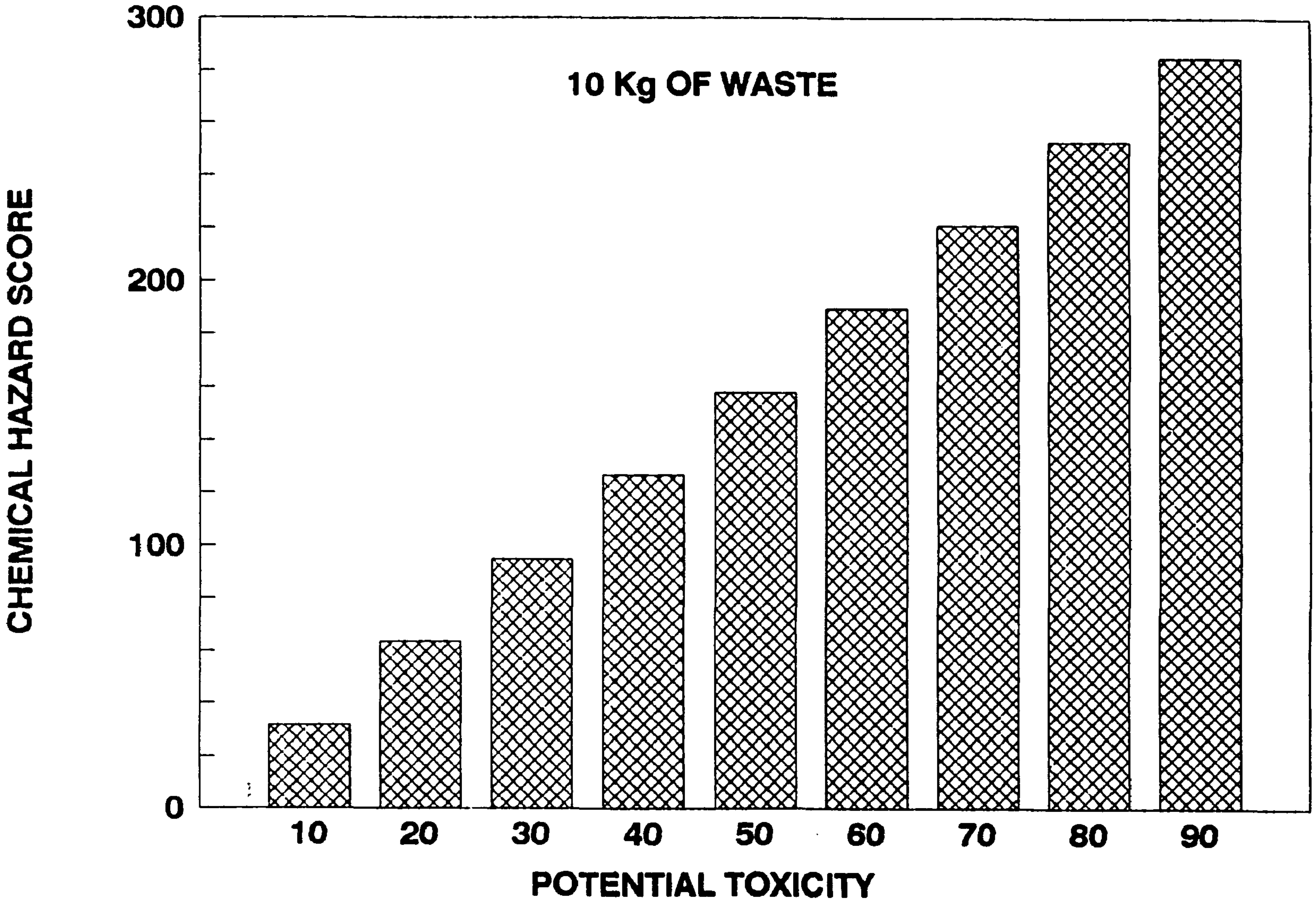


Figure 4.3 Relationship of Chemical Hazard Score to the Potential Toxicity Factor when Waste Quantity Is Held Constant

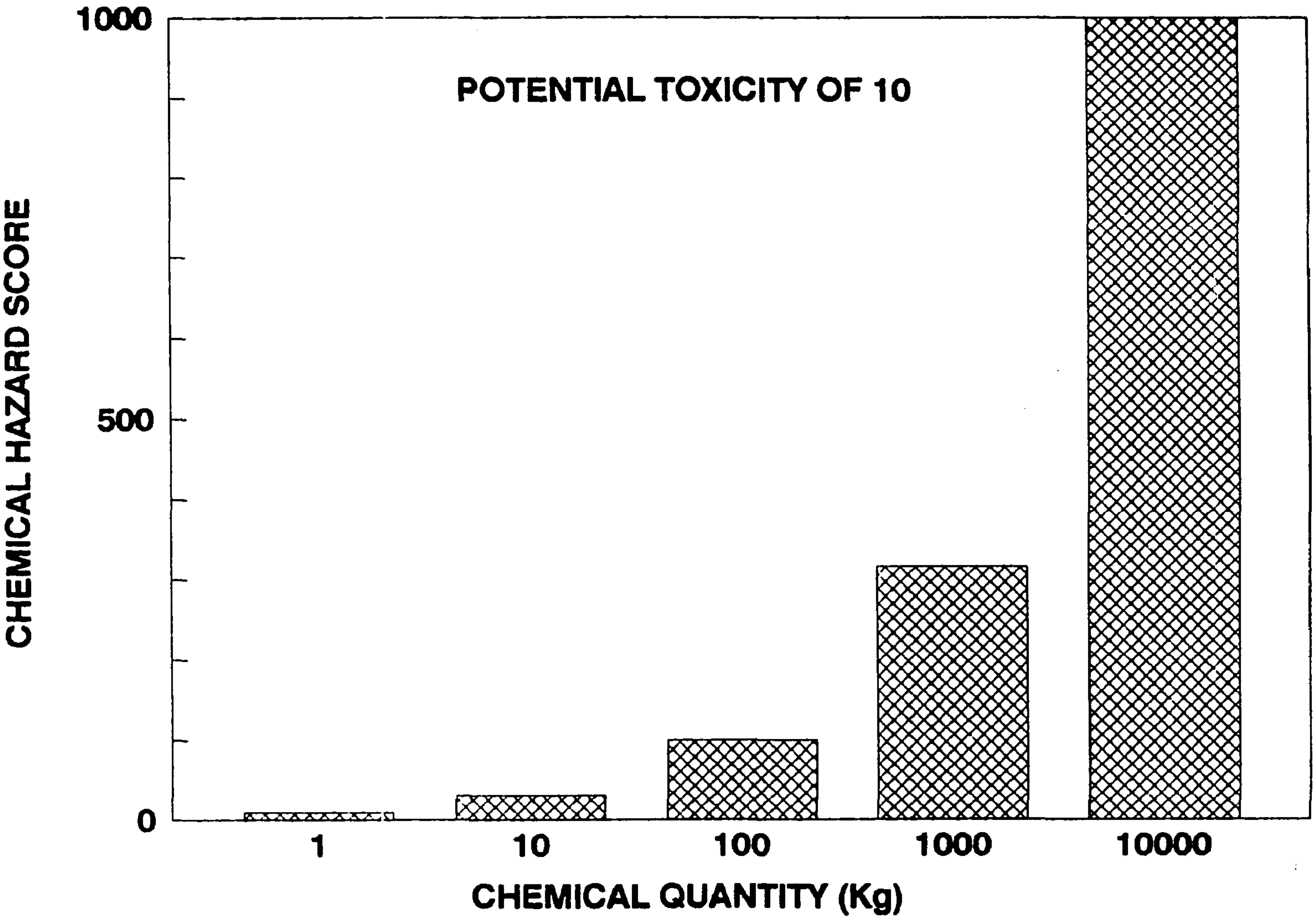


Figure 4.4 Relationship of Chemical Hazard Score to Waste Quantity when the Potential Toxicity Factor Is Held Constant

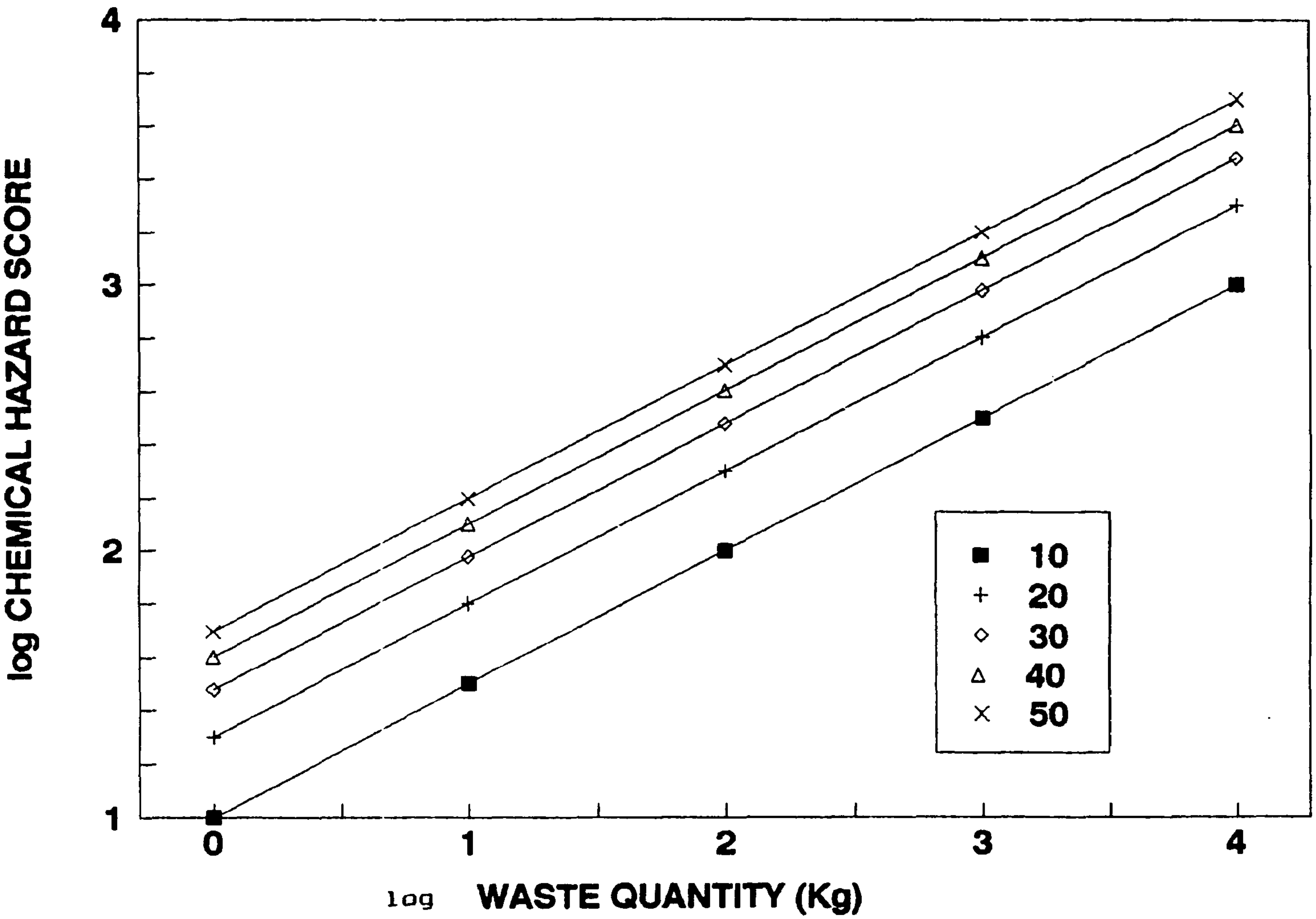


Figure 4.5 Relationship of Log Chemical Hazard Score to Log Waste Quantity for Selected Potential Toxicity Factors

to waste quantity, is defined as constant for all potential toxicity factors.

The interactive function shown in Figure 4.5 takes the form of a power function and is described by the equation

$$Y = aX^{b}$$

where Y is the Chemical Hazard score (CH), a is the intercept of the potential toxicity factor at 1 kg of waste where chemical hazard equals potential toxicity (PTF), X is the waste quantity (Q), and b is the slope of the line describing the relationship between chemical hazard score and waste quantity for any potential toxicity factor (0.5). Substituting the term definitions into the equation, this becomes

$$CH = PTF(Q^{0.5})$$

The concept of logarithmic rise in chemical hazard score with logarithmic rise in waste quantity is better illustrated in Figure 4.6 where the equation is redrawn up to a potential toxicity factor of 90 on linear scale and truncated at 1000 points. This figure also better illustrates the continuous nature of the relationship where the potential toxicity factor is allowed to range from 1 to a current high of 84 depending upon the toxicological evaluation of each contaminant.

The chemical hazard score of an identified contaminant is calculated using the above equation. The identity and quantity of contaminant has

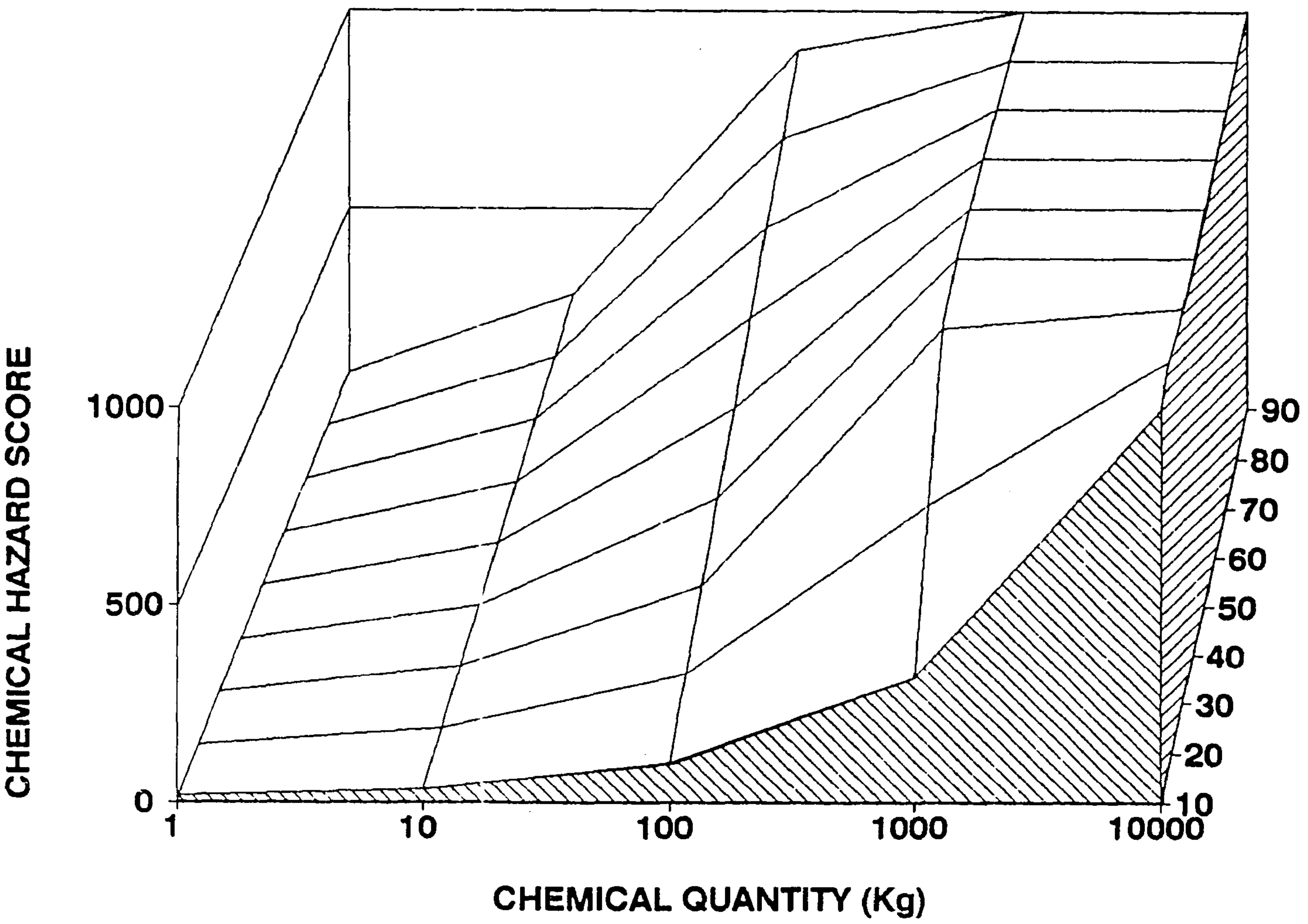


Figure 4.6 Three Dimensional Surface Diagram Showing the Relationship Between Chemical Hazard Score and Waste Quantity for Continual Potential Toxicity Factors

already been determined in the preceding waste quantification step. To score chemical hazard, obtain the contaminant potential toxicity factor (in Appendix A of the model document) and apply this as the intercept, PTF. The contaminant waste quantity is raised to the 0.5 power, and the contaminant chemical hazard score is calculated. Through repeated use of the equation, the chemical hazard score of each contaminant on site is calculated. The site chemical hazard score is obtained by adding the individual contaminant chemical hazard scores until a maximum site chemical hazard score of 1,300 points is obtained. This is the maximum site chemical hazard score as discussed above in the de minimus, de maximus subchapter.

For waste characterization scoring, the potential toxicity factor relationships between waste quantity and chemical hazard score have been replaced by four potential toxicity factor lines representative of the waste characterization classifications in Table 3.4. These relationships are plotted in Figure 4.7 in a format similar to Figure 4.5. Because the relationships are again expressed in logarithmic form, the equation for the waste characterization relationships takes the power function form. The waste characterization types A, B, C, and D are assigned the potential toxicity factors of 20, 15, 10, and 5 respectively. As visualized in Figure 4.7, the slope of all lines is the same, 0.5, and corresponds to that derived for identified contaminants. Therefore, the equation for calculation of the chemical hazard score for any of the four waste characterization relationships is the same as above for identified contaminants. Because there are four fixed relationships between chemical hazard score and waste quantity as

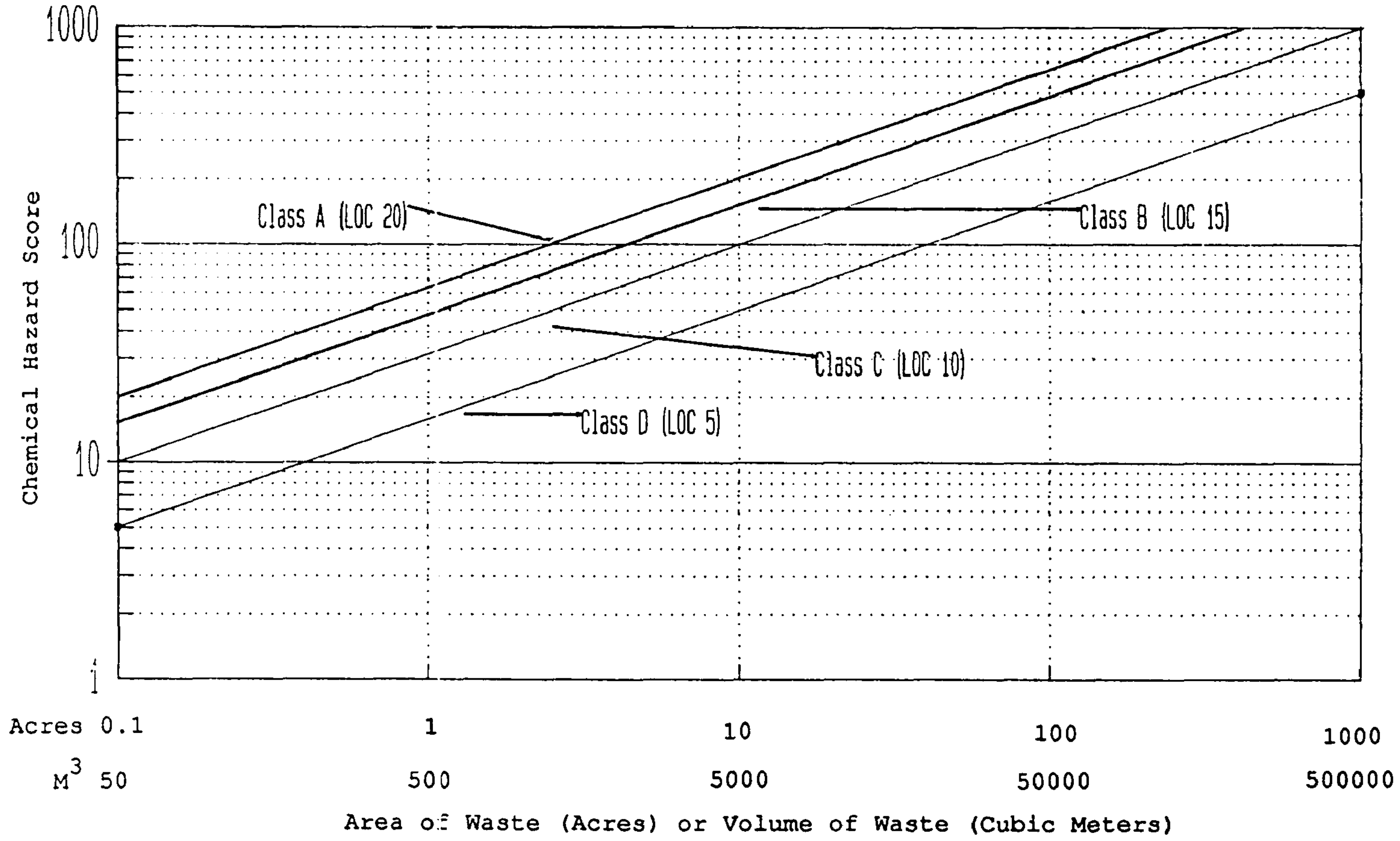


Figure 4.7 Relationship of Log Chemical Hazard Score to Log Waste Quantity (Acres or Volume of Waste) for the Waste Characterization Scoring Method

defined in the waste characterizations, the equation for each waste category are presented below.

$$CH_D = 5(Q^{0.5})$$

$$CH_C = 10Q^{0.5})$$

$$CH_B = 15(Q^{0.5}) \text{ and,}$$

$$CH_A = 20(Q^{0.5})$$

for waste characterization types D, C, B, and A, respectively. Waste quantity, the independent variable, is entered into the appropriate equation in terms of acres ranging from 0.1 to 1,000 acres. If the waste quantity has been calculated in terms of cubic meters, the acreage value is obtained by dividing the cubic meter value by 500.

The final total chemical hazard category score is calculated by adding the specific chemical waste hazard score to the waste characterization score. Because the proportions of identified and unidentified wastes have been accounted for in waste quantification, a simple total is calculated, not a weighted total as in the 1983 SAS.

The maximum total chemical hazard score is 1300 points. This value is derived according to the logic in the de minimus, de maximus subchapter above where it was determined that, at some level, increasing the chemical hazard score for large quantities of waste becomes meaningless.

However, an additional set of points above the single contaminant maximum of 1000 points provides for an important contribution of additional contaminants on site. At the same time, the 1300 maximum places the chemical hazard compartment on approximate parity with the maximum value which could be obtained in an environmental compartment and allows for compartment equality but not dominance of the total site score.

This method applies a "degree of hazard" approach to the scoring. By having chemical hazard and quantity scales which are not limited to a few ranges of points or quantities, it takes more of a less toxic contaminant to elicit the same or greater toxicological response as that of a more toxic compound. While this concept is also true in the 1983 SAS (as shown in Figure 4.8 where Figure 3.3 is converted to graphical scoring form similar to Figure 4.5) limitation to a few score values and different slopes of the four potential toxicity ranges destroys score discrimination and distorts the relationship among contaminants. The calculation of a chemical hazard score by application of a single equation allows for simple derivation of the score without the limitations and distortion shown in Figure 4.8.

This reduces the danger of obtaining false discrimination as determined in the chemical hazard score. For example, two sites each with a single, similar contaminant at similar quantities could obtain very different chemical hazard scores. If site A had 2490 kg of a contaminant with a potential toxicity factor of 19, it would score 50 chemical hazard points in the 1983 SAS. If site B had 2510 kg of a

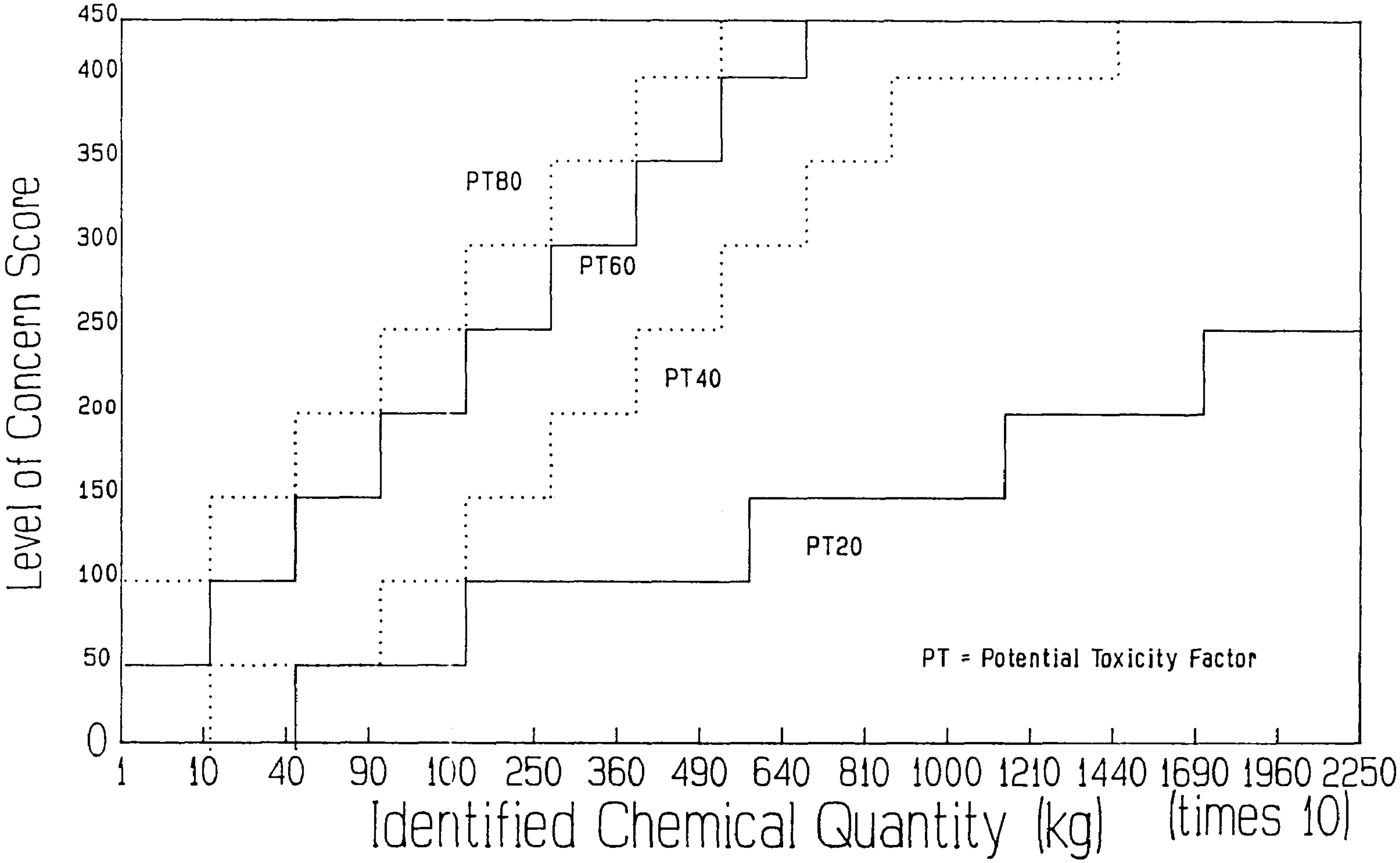


Figure 4.8 1983 Site Assessment System Identified Chemicals Hazard Scoring Nomograph Converted to Graphical Form

contaminant with a potential toxicity factor of 21, it would score 150 points in the 1983 SAS. This difference of 100 points is 22% of the total 450 point range available in the 1983 SAS. The result would be false discrimination with site A potentially being identified as a site of little concern, while site B could be considered of much greater concern. In fact, logic would say there is probably little difference between the two sites, at least in terms of chemical hazard. In the RSAS, the chemical hazard scores would be 948 for site A and 1,000 for site B, both significant scores but not substantially different. In this case, the 52 point difference is 5% of the 1,000 points available for a single contaminant on site.

4.1.4 Migration Potential

In the 1983 SAS, the release potential factor was intended to assess the mobility of site contaminants and was defined in terms of the physical state of the waste materials at the time of disposal (MDNR, 1983). Once a contaminant has escaped containment, however, the chemical nature of the contaminant and the receiving environment is more important in determining mobility than the physical state of the contaminant at the time of its disposal or release. For example, a solid such as road salt has a high solubility and becomes mobile upon release and exposure to water. A liquid could be soaked up by a porous soil or flow over the surface of an impervious soil. It could be quickly sorbed by a soil if it had low water solubility and high sorptive capacity (Freeze and Cherry, 1983), as in the case of PCBs, or it could be mobile as in the above case of road salt or acetone or phenolic compounds due to a low sorptive capacity and high water solubility. These factors, combined with degradation, are generally described as environmental fate factors (Rand and Petrocelli, 1985). The release potential factor must be combined with some estimate of environmental fate to better describe migration potential.

Migration potential must consider those characteristics of the waste material and its containment which determine the liklihood that contaminants may be released to the environment and that they may migrate off-site. It replaces the release potential parameter of the 1983 SAS by including an environmental fate factor in the calculation. In RSAS, migration potential is calculated according to the following formula:

$$MP = RPF \times EFF$$

where MP is the migration potential, RPF is the release potential factor, and EFF is the environmental fate factor.

The release potential factor depends on the physical state of the contaminants on site at the time of their disposal or release and the condition of the containment structure or its ability to prevent contaminant release. In this context, the release potential factor remains unchanged from the 1983 SAS. The environmental fate factor depends on the nature of the contaminant (Mackay, 1985), the predicted contaminant behavior in the environment (Rosenblatt et al., 1985) and the nature of the environment it has been released into (Rosenblatt and Dacre, 1985 and Southworth et al., 1985).

The environmental fate factor is used as a modifier to evaluate the probability that a contaminant, once it has escaped its containment, will reach an environmental resource. In this regard, the environmental fate factor relates to contaminant mobility and is affected by the contaminant's physical/chemical properties (such as water solubility and adsorptive or bonding capacity) (Mackay, 1985). High contaminant mobility would be expected to increase the rate of contaminant movement in the environment while low contaminant mobility would reduce movement rate.

Under conditions of high contaminant mobility, the environmental fate factor increases the migration potential and therefore the number of points in the potential exposure category. This provision is important because some contaminants are capable of rapid movement through or over soils due to their low adsorptive capacity and high water solubility. Similarly, some contaminants may quickly escape to the atmosphere due to their high volatility and low adsorption by soils. Thus the environmental fate factor will be allowed to increase the compartment migration potential up to its maximum value of 2.0 but not above this value. Conversely, under conditions of low contaminant mobility, the environmental fate factor decreases the migration potential and therefore the number of points in the potential exposure category. Reduction in points is appropriate when a contaminant has a very low water solubility or a high adsorption or complexing capacity which would bind it into soils in the immediate vicinity of its point of release.

The general mechanism is to derive a physical parameter index which is integrated with a chemical specific parameter to obtain the environmental fate factor for each resource compartment. The physical parameter index describes the impeding medium while the chemical parameter is some property which affects contaminant mobility in each medium. These parameters are described below and developed specifically for each resource compartment, ground water, surface water, and air. When the specific contaminants are unknown and the site is defined in general terms by waste characterization, the chemical parameter has to be derived in general terms as well.

The physical parameter index takes into account the medium parameters which impede contaminant migration. These parameters are specific to the ground water, surface water and air compartments and are developed in the sections below. Generally, the physical parameter index consists of a medium type index and some other descriptive index such as soil thickness, site slope, or near surface soil type. The physical parameter index is developed by multiplying the medium type index by the extent index according to the formula:

$$PPI=MTI*EI$$

where PPI is the physical parameter index, MTI is the medium type index and EI is the extent index.

The environmental fate factor is derived by integrating the above physical parameter index with a contaminant specific parameter which describes the inherent capability of the contaminant to migrate. The contaminant specific factors are those which describe the behavior of the contaminant and its relationship to the environment. These factors are adsorptive capacity or organic complexing ability, water solubility, and volatility in the ground water, surface water and air compartments respectively. When site contaminants are unknown and the site has been evaluated by the waste characterization method, the chemical parameter is also derived by that method (Chapter 3.1.4.5). In all cases, the factor is derived by entering a table with the physical parameter index and the contaminant parameter.

4.1.4.1 Ground Water Compartment Environmental Fate Factor

Physical Parameter Index

In the ground water compartment, the physical parameter index depends upon the characteristics of the soils overlying the saturated zone, which impede water and contaminant flow, and the thickness of those soils. The primary characteristics which affect flow velocity are porosity and permeability of the medium and its sorptive capacity. Porosity and permeability are functions of the texture of the medium (Freeze and Cherry, 1987 and Water Science and Technology Board, 1990) and can be characterized by the description of the medium itself. Thus, permeability decreases as soil texture progresses from gravel through sand, silt and clay and the velocity of contaminant flow decreases accordingly. Loam or peat soils are a special case because, while water flow through them may be reasonably rapid, contaminant absorption may be quite high depending on contaminant chemistry.

This decrease in velocity with soil type has been found to correlate with the fraction of organic content of the soil (Dzombak and Luthy, 1984 and Abdul et al., 1986). A complicating factor in this adsorption is whether a contaminant has become adsorbed by small colloidal particles which would interfere with adsorption by the soil. In this case, soil adsorption would be limited and a contaminant, which otherwise would be expected to bind in the soil, might be transported fairly freely when bound to a colloidal particle, depending on the porosity/permeability of the soil.

Overlying soil thickness affects transport time in a simple fashion: regardless of soil type, the thicker the medium the longer it takes to traverse the medium (Water Science and Technology Board, 1990). It is independent of medium type and is merely related to the distance to the saturated zone. Therefore, a simple index which rates thin soil zones as presenting the greatest risk for transport to the saturated zone has been developed.

The ground water compartment physical parameter index is derived by multiplying the medium type index (Table 4.2) by the medium thickness index (Table 4.3). For those soils which consist of more than one layer, the medium type index should be derived using a weighting technique. The medium index for each layer should be multiplied by the

Table 4.2 Ground Water Compartment Medium Type Index for Development of the Physical Parameter Index

Medium	Index
gravel	10
sand	9
loam/peat	6
silt	4
clay	2

Table 4.3 Ground Water Compartment Medium Thickness Index for Development of the Physical Parameter Index

Thickness	Index
<1m	10
1-5m	8
5-10m	6
10-20m	4
>20m	2

thickness of the layer, all layer indices added together and then divided by the total thickness of the unsaturated zone. This would weight the index toward the dominant layer(s).

Organic Contaminants

For organic contaminants, water solubility and adsorptivity by the environment operate as independent characteristics although they can be predicted using a single chemical parameter. Adsorptivity has been related to the fraction of organic material in soils and can be predicted by the octanol/water partition coefficient (log Kow) (Abdul and Gibson, 1986). It has also been observed that there is an inverse relationship between log Kow and water solubility of hydrophobic organic compounds (Chiou et al., 1983). Essentially, as the log Kow increases for various organic compounds, soil adsorption of the compound increases while the water solubility decreases. Using this relationship, four log Kow ranges were selected which range from water soluble/low adsorption (log Kow <1.5) to low water solubility/high adsorption (log Kow >3.5).

The Environmental Fate factor is obtained from Table 4.4 by calculating the PPI and finding the appropriate column which corresponds to the log Kow of the compound under consideration.

Inorganic Contaminants

The behavior of the inorganic contaminants, particularly the heavy metals, has proven to be difficult to predict in a simple model system

Table 4.4 Ground Water Compartment Organic Contaminant Environmental Fate Factor Derived from the Physical Parameter Index and Contaminant Log Kow

	Organic Contaminant Log Kow			
PPI	<1.5	1.5-3.0	3.0-4.5	>4.5
76-100	2.0	1.5	1.25	1.0
51-75	1.5	1.25	1.0	0.8
26-50	1.25	1.0	0.8	0.6
4-25	1.0	0.8	0.6	0.4

(Bourg and Mouvet, 1984 and Lee, 1985). While the same conceptual structure of physical medium integration with contaminant chemical characteristics (as developed for organic contaminants) must be developed for the metals, the factors governing metals behavior in soil systems are much more complex than for organics.

The greatest problem in predicting metal behavior is their ability to exist as a variety of species with very different chemical characteristics. This speciation changes readily depending on several factors, the most important of which are pH and Eh (Dragun, 1987). This becomes even more complex when considering contamination sites because of the diversity of metal complexes in the wastes. The pH and Eh conditions of the waste determine metal stability and solubility before release. However, when wastes escape from their containment, soil conditions may buffer and alter the contaminant chemical conditions and this can result in redistribution of chemical speciation. This adds up to extremely complex site specific conditions and great variability in metal mobility.

Development of a detailed medium type index should take several factors into account. Soil character and structure, pH, Eh, cation exchange capacity, and adsorption combine to govern metal speciation and mobility (Dragun, 1987 and Dzombak, et al., 1987). However, a general correlation of soil type with mobility is adequate for estimating comparative site risk. Eh and pH ranges cannot be reliably generalized by soil type (Freeze and Cherry, 1985 and Dragun, 1987) and will not be incorporated into the medium index. However, adsorption on inorganic and organic bases correlates loosely with cation exchange capacity and organic content of the soil (Freeze and Cherry, 1985 Dzombak, et al., 1987). Therefore, a loose association between soil type/texture with cation exchange capacity and the fraction of organic carbon can be used to derive the medium index.

After comparing the above parameters with medium type, the same correlation with probability of organic contaminant movement was found for inorganic contaminants. Therefore, the medium type index developed for organic contaminants is used for inorganic contaminants. Similarly, the effect of medium thickness on inorganic contaminant migration is also the same as for organic contaminants and the thickness index remains unchanged.

The environmental fate factor is derived by integration of the physical parameter index with some chemical characteristic which describes metal solubility. Derivation of the metal solubility factor is very difficult because of the speciation problems discussed above. The variables affecting speciation and solubility are too numerous to incorporate into a simple tabulation. Therefore, inorganic contaminant mobility is predicted by setting up very general, broad mobility scales (mobile, moderately mobile and immobile) for each inorganic contaminant over a range of pH values. This mobility table (Table 4.5) has been derived by examination of pH and water solubility which were then compared to experience obtained from contamination sites. The ground water environmental fate factor is derived from Table 4.6 using these parameters.

Table 4.5 Ground Water Compartment Inorganic Contaminant Mobility

pH	Al	As	B	CN	Cd	Cu	Cr	Hg	Ni	Pb	Zn
4	M	M	M	I	M	M	M	M	M	MM	M
5	M	M	M	I	M	M	M	M	M	MM	M
6	M	M	M	I	MM	M	MM	MM	MM	MM	M
7	MM	M	M	I	MM	M	I	MM	MM	I	M
8	I	MM	MM	I	I	M	I	I	MM	I	MM
9	I	I	MM	I	I	M	I	I	I	I	MM

M = mobile, MM = moderately mobile, I = immobile

Table 4.6 Ground Water Compartment Inorganic Contaminant Environmental Fate Factor

PPI	Mobile	Moderately Mobile	Immobile
76-100	2.0	1.5	1.0
51-75	1.5	1.0	0.8
26-50	1.0	0.8	0.6
1-25	0.8	0.6	0.4

4.1.4.2 Surface Water Compartment Environmental Fate Factor

Physical Parameter Index

In the surface water compartment, the environmental fate factor depends on physical parameters related to soil infiltration versus overland runoff and water solubility of the contaminant (Southworth, et al., 1985. Soil infiltration is related to the amount of water reaching the soil surface (cumulative soil pore volume) and permeability (retardation and seepage velocity) of the surface soils (Small and Mular, 1987) which loosely corresponds to soil type (Freeze and Cherry, 1985). The probability of overland runoff correlates with precipitation rate and site slope (USEPA, 1984).

Annual average precipitation varies by 12 inches over the entire state (28 to 40 inches per year) (Miller and Twenter, 1985) a level of variation insufficient to correlate with overland flow rate. Overland runoff rate can be quite complicated, governed principally by storm events, land slope, and surface soil type (Nacht, 1980) requiring substantial site specific data. Because site specific rainfall records are not likely to be available, regional rainfall conditions are not much different from statewide average conditions, and contaminant release could have happened over a several year period at older sites (making one year site specific records meaningless), relative rainfall quantity will not be considered in development of the physical parameter index.

Site slope and surface soil type are important site parameters governing overland flow (Nacht, 1980) and are readily available or easily estimated. Therefore, the physical parameter index is derived by multiplying the medium type index (Table 4.7) by the slope Index (Table 4.8).

Organic Contaminants

Water solubility is the only chemical specific parameter applied to the surface water compartment environmental fate factor. While organic compounds may adsorb onto soil particles, generally in relation to their log Kow, and inorganic compounds can exist in a variety of particulate forms (precipitates, adsorbed, or compound particles) (Mackay, 1985), existence in these forms are difficult to predict. In addition, particle transport under conditions other than erosion or flood events are fairly minor relative to solute transport (Nacht, 1980) and therefore transport of these particles will not be considered. The environmental fate factor is obtained from Table 4.9 by calculating the PPI and finding the column which corresponds to the water solubility of the contaminant under consideration.

Inorganic Contaminants

Inorganic contaminants water solubility is very complex and, as discussed in the ground water compartment, depends upon metallic speciation pH, and Eh (Mackay, 1985 and Dragun, 1987). Therefore, water solubility is replaced by a mobility parameter which takes pH into

Table 4.7 Surface Water Compartment Medium Type Index for Development of the Physical Parameter Index

Medium	Index
gravel	2
sand	4
loam/peat	6
silt	8
clay	10

Table 4.8 Surface Water Compartment Slope Index for Development of the Physical Parameter Index

Slope	Index
all surrounding terrain higher	0
< 3%	2
3-5%	4
5-8%	6
> 8%	8

Table 4.9 Surface Water Compartment Organic Contaminant Environmental Fate Factor Derived from the Physical Parameter Index and Contaminant Water Solubility

	Water Solubility (ppb)			
PPI	<1	1-1.5E+1	1.6-1E+3	>1E+3
4-20	0.4	0.6	0.8	1.0
21-40	0.6	0.8	1.0	1.25
41-60	0.8	1.0	1.25	1.5
61-80	1.0	1.25	1.5	2.0

account in predicting the probability of conversion to a soluble species. As in the ground water compartment, it is necessary to develop a predictor of mobility before deriving the surface water environmental fate factor. Unlike the ground water compartment, however, a wide range of pH and mobility correlations is not needed because the pH of rainwater is fairly constant statewide (around 5.3) (USEPA, 1980). Buffering of overland flow is difficult to predict and measurement would be an unreasonable requirement for application of the model. Therefore, a worst case scale of pH 5.0 is used for predicting metal mobility in overland flow from Table 4.10. Applying these parameters, the surface water inorganic contaminant environmental fate factor is obtained from Table 4.11.

4.1.4.3 Surface Water Contamination By Contaminated Ground Water

In some situations, there may be a potential for contamination of surface water by contaminated ground water. Two conditions must be met before a site can be scored for this potential. First, there must have been a determination that contaminantion of surface water by overland flow is not possible, i.e. there is a barrier between the site and the surface water body or the site is at a lower elevation than the surface water body. Second, ground water contamination must have been detected at the site. These conditions are imposed in order to eliminate the chance of "double counting" where the surface water compartment has already been scored for potential contamination.

Table 4.10 Inorganic Contaminant Mobility in Surface Water

	Inorganic Compound							
	As	CN	Cd	Cu	Cr	Ni	Pb	Zn
Mobility Factor	M	I	M	M	MM	M	MM	M

I = Immobile
MM = Moderately Mobile
M = Mobile

Table 4.11 Surface Water Compartment Inorganic Contaminant Environmental Fate Factor derived from the Physical Parameter Index and Contaminant Mobility

	Mobility Factor		
PPI	Immobile	Moderately Mobile	Mobile
4-20	0.6	0.8	1.0
21-40	0.8	1.0	1.25
41-60	1.0	1.25	1.5
61-80	1.25	1.5	2.0

Assessing this potential for contamination requires a different environmental fate factor than derived above for overland flow contamination of surface water because the path of contaminant flow depends on soil infiltration and in-soil movement. The factors to be considered, therefore, depend upon the physical parameter index derived in the ground water compartment and the ground water slope and distance to the surface water body.

In the ground water compartment, the physical parameter index depends upon the characteristics of the soils of the unsaturated zone (which impede water and contaminant flow) and the thickness of the zone in question. These indices determine the rate of infiltration. Modified by the water table slope and distance from the site to the surface water body, the revised physical parameter index relates to the probability of subsurface contaminant movement to the surface water body.

The water table slope index is derived by calculating the water table slope to the surface water body and entering Table 4.11. The slope is calculated by subtracting the elevation of the surface water body at risk from the water table elevation at the contaminated monitoring well nearest to the surface water body. If the evidence for ground water contamination is a contaminated private drinking water well, determine whether the well is completed below a confining layer. If it is not completed below a confining layer, assume that the water table aquifer elevation coincides with the water level reported in the well log. If the well is completed below the confining layer, assume that the top of the confining layer reported in the well log coincides with the water table elevation. In this situation, because the true water table elevation would be somewhat higher than estimated, if a negative slope is calculated, assume that the slope is less than 3% in Table 4.12.

The distance to surface water index is derived by estimating the distance to the nearest surface water body at risk and entering Table 4.13. The distance to surface water is estimated from the monitoring or drinking water well showing contamination nearest to the surface water body using the topographic map for the site.

In the special case where there is a known underground conduit such as a drainage tile to surface water or there is free product floating on or displacing the water table, the ground water compartment PPI must be altered. This is done by assuming the medium in the medium type index is gravel and that the thickness of the medium thickness index is <1 meter so that the PPI becomes 100 for this special case.

Once these indices have been derived, they are multiplied by each other to derive a horizontal migration index ranging from maximum of 1.25 to a minimum of 0.49. This index is then multiplied by the ground water physical parameter index and used to enter the environmental fate factor table for organic (Table 4.14) or inorganic contaminants (Table 4.15). The Environmental Fate Factors in both tables have been reduced to scales ranging from 1.0 to 0.4 or 0.2 instead of 2.0 to 0.4 because the relative importance of migration by this mechanism is considered less than that of overland migration.

Table 4.12 Water Table Slope Index for Derivation of the Physical Parameter Index for Surface Water Contaminated By Contaminated Ground Water

Water Table Slope	Index
>8%	1.0
5-8%	0.9
3-5%	0.8
<3%	0.7

Table 4.13 Distance To Surface Water Index for Derivation of the Physical Parameter Index for Surface Water Contaminated By contaminated Ground Water

Distance To Surface Water	Index
<1/16 mile	1.25
1/16-1/8 mile	1.0
1/8-1/4 mile	0.85
>1/4 mile	0.7

Table 4.14 Organic Contaminant Environmental Fate Factor for Surface Water Contaminated By Contaminated Ground Water

	Organic Contaminant Log Kow			
PPI	<1.5	1.5-3.0	3.0-4.5	>4.5
76-100	1.0	0.9	0.8	0.7
51-75	0.9	0.8	0.7	0.6
26-50	0.8	0.7	0.6	0.5
4-25	0.7	0.6	0.5	0.4

Table 4.15 Surface Water Contaminated By Contaminated Ground Water Inorganic Contaminant Mobility Factor

	Mobility Factor		
PPI	Mobile	Moderately Mobile	Immobile
76-100	1.0	0.9	0.8
51-75	0.8	0.7	0.6
26-50	0.6	0.5	0.4
1-25	0.4	0.3	0.2

4.1.4.4 Air Compartment Environmental Fate Factor

In the air compartment, the environmental fate factor evaluates the inherent potential for contaminants to be released to the ambient air. A structurally intact container, such as an underground storage tank or intact barrel, is presumed to have no potential for contaminant release to the air. On the other hand, partially disintegrated or leaky drums, even if buried, may have a significant potential for release of their contents to the ambient air through diffusion into the soil pore space and subsequent diffusion to the ambient air.

While evaluation of the release potential factor remains unchanged from the 1983 SAS, the thickness of soil cover sufficient to prevent release to the air has been changed. In the 1983 SAS, only contaminants contained in the top 1.4 centimeters (1/2 inch) of material are considered available for evaporation and wind dispersion or, conversely, protected from dispersion. This is an unrealistic assumption for long term consideration of diffusion and evaporation because volatile organic compounds and mercury have been found to escape to the atmosphere from soil depths to three meters depending on the nature of the soil (Anderson and Hussey, 1989). Therefore, a thickness of 15 cm. (approximately 6 inches) of soil is more appropriate in this case (Teoh, Personal Communication).

The Physical Parameter Index (Table 4.16) depends upon whether there are exposed liquids in lagoons, open tanks, or open barrels, and the characteristics of the near surface soils where contaminants have been

Table 4.16 Air Compartment Physical Parameter Index

Medium	Index
lagoon/open barrel	10
gravel	10
sand	9
loam/peat	6
silt	4
clay	2

released. Contaminants in lagoons or open barrels (at the soil surface) have no impediment to evaporation. For this reason, a worst-case physical parameter index score of 10 is assigned to contaminants in these structures in Table 4.16. For contaminated soils or covered containment structures, the ability of a soil to impede contaminant release to the atmosphere is related to the pore space of the overlying surface soil (Teoh, personal communication) and the pore space is related directly to soil type (Freeze and Cherry, 1985).

Organic Contaminants

While there may be some further impediment to volatilization due to adsorption to soil organic material, the lack of extensive data on adsorption capacity of various soil fractions for individual volatile compounds prohibits the use of this parameter in determination of the air compartment environmental fate factor. During development of the ground water environmental fate factor for organic contaminants, it was demonstrated that log Kow is an adequate predictor of the sorptive capacity of a soil. the scale used, however, is quite broad (<1.0 to >7.0) while significant volatility might be expeced principally in the lower end of the log Kow scale range (<2.5). The discrimination of log Kow in this narrower scale is not be adequate for prediction of contaminant volatility and a more direct prediction measure is needed. This conclusion is further justified by comparison of compound log Kow and vapor pressure values (Figure 4.9). Simply stated, it appears that a low log Kow value (and therefore low organic material adsorption) corresponds to high vapor pressure (and high volatility) while a high

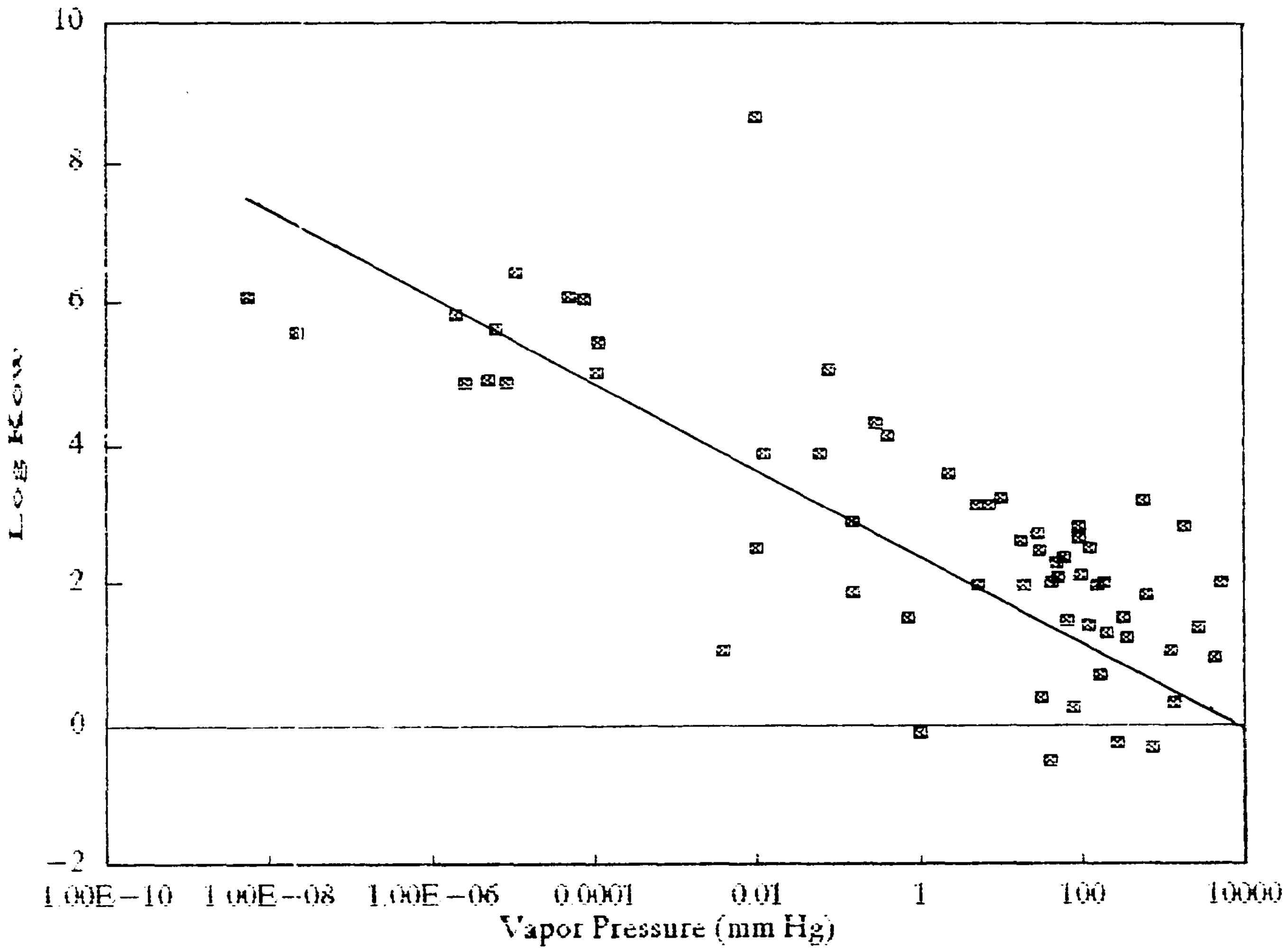


Figure 4.9 Relationship Between Log Kow and Vapor Pressure

log Kow tends to correspond to a low vapor pressure value. The potential for contaminant escape to the air can, therefore, be represented by a single parameter, vapor pressure.

The vapor pressure value for the site contaminant is obtained from Appendix A of the scoring model (Appendix A of this document). If more than one organic contaminant is present, a weighted vapor pressure value is obtained by multiplying the vapor pressure value for each contaminant by the quantity of contaminant present, adding these values, and dividing the sum by the total quantity of waste present. The environmental fate factor is obtained from Table 4.17 using the PPI and the weighted vapor pressure value.

Inorganic Contaminants

There is no need to develop a separate environmental fate factor for inorganic compounds because few are considered volatile. Volatility of inorganics can be considered using the same matrix developed for organic compounds because, for those compounds (for example, mercury and HCN) which can be considered volatile, vapor pressure values are available.

4.1.4.5 Environmental Fate Factor By Waste Characterization

The environmental fate factors developed in the previous three subsections utilize chemical properties specific to known contaminants and their behavior in the ground water, surface water, or air media. However, the specific contaminants at an environmental contamination

Table 4.17 Air Compartment Environmental Fate Factor

	Vapor Pressure (mm. Hg @ 20 deg.C)			
PPI	<=0.002	>0.002-<=0.1	>0.1-<=1.0	>1.0
2	0.25	0.50	0.75	1.00
4	0.50	0.75	1.00	1.25
6	0.75	1.00	1.25	1.50
8	1.00	1.25	1.50	1.75
10	1.25	1.50	1.75	2.00

site are often unknown. Under these conditions, the site is evaluated according to the waste type and chemical hazard is also evaluated by waste type. This subsection provides guidance for development of the environmental fate factor via a waste type method.

The factors used in the various media to describe the physical parameter indices do not change when evaluating a site by waste characterization because they are specific to the site and not the contaminants. Therefore, the physical parameter Indices derived in the ground water, surface water, and air subchapters are retained.

The waste type characterization method of chemical hazard scoring identifies five hazard groups (Table 4.1) by waste type based on a grouping of the sources. While there is no constant group of contaminants exclusively identified with one of the groups, broad contaminant characteristics can be identified for each source within the five groups. Once the general types of chemicals have been estimated, their behavior in the three media can be predicted on a general basis in a manner similar to that done for inorganic contaminants. That is, the wastes can be generally characterized as mobile, moderately mobile, or immobile.

Mobility evaluation was accomplished for each medium in the following manner. First, the wastes generally associated with each waste category were identified. Second, they were roughly divided into inorganic and organic portions with the dominant portion being identified. Third, the organic portions were typified by log Kow, water solubility, or vapor pressure for application to the ground water, surface water, and air media respectively. The inorganic portions were typified by complexation and water solubility while assuming they were not volatile. Finally, when considering ground water, if the categories were dominated by water soluble wastes they were graded as mobile while, if they were dominated by higher log Kow values and inorganic compounds, they were graded as moderately mobile. In the case of surface water, inorganics were considered less likely to be immobilized than in soils and were therfore defined as mobile. In the case of the air compartment, organic wastes dominated by high vapor pressures were defined as mobile while those dominated by inorganic wastes were defined as generally immobile. The mobility classifications applied to each waste type category for each of the environmental media are shown in Table 4.18.

Once the mobility has been characterized for the waste categories, the environmental fate factor is derived from Table 4.19. The table is entered using the physical parameter index appropriate to the medium being evaluated and the mobility characterization from Table 4.18. Note that if a physical parameter index of 2 is derived for the air medium, an environmental fate factor of 0.25 is used.

4.1.5 Population At Risk

Population at risk is part of the targets portion of the potential exposure category in each environmental compartment. In the 1983 SAS, it assesses the potential size of the human population that may be affected by an environmental contamination site if a release from that

Table 4.18 Waste Characterization Contaminant Mobility According to Environmental Medium

Environmental Medium	Waste Type Category A	B	C	D	E
Ground Water	MM	MM	M	M	I
Surface Water	MM	M	M	M	I
Air	M	MM	M	MM	I

I = Immobile
MM = Moderately Mobile
M = Mobile

Table 4.19 Waste Characterization Environmental Fate Factor

Physical Parameter Index			Mobility Parameter		
GW	SW	Air	Mobile	Moderately Mobile	Immobile
76-100	61-80	10	2.0	1.5	1.0
51-75	41-60	8	1.75	1.25	0.75
26-50	21-40	6	1.5	1.0	0.5
4-25	4-20	4	1.25	0.75	0.25

site were to occur. Some aspects of population at risk, such as refinement of directionality in ground water, blanket application of the 1/2 mile radius to all compartments, and zone of influence or maximally exposed individual (MEI) concepts were considered during revision of the parameter in RSAS.

Analysis for all compartments begins with a 1/2 mile zone of influence determination and is extended or truncated according to environmental compartment needs. The furthest known extent of contamination is defined as the contamination site. Interconnecting arcs of 1/2 mile radii (for estimating future potential contamination) are drawn using the furthest points of contamination as the foci of each arc. This includes the extent of a migrated plume, either ground or surface water, or contaminants deposited by air transport when the contaminants are known to have originated from the primary site.

4.1.5.1 Ground Water

In the ground water compartment, a plume of contaminants generally moves directionally from a site driven by ground water flow rather than expanding radially in all directions (Water Science and Technology Board, 1990, USEPA, 1988, Story Chemical Co. site, Site No. 7 in Appendix B and, Gelman Sciences site, site No. 49 in Appendix B). For this reason, wells down-gradient from the site will most likely intercept contaminants migrating in the ground water flowing away from the site. Furthermore, as a contaminant plume migrates from a site, its direction of flow may be spread or diverted by subsurface features or significant water withdrawal such as large capacity wells (McKay, 1984, Freeze and Cherry, 1987, and USEPA, 1988). Ground water flow directional information about a site allows greater focus in the RSAS than in the 1983 SAS model.

Therefore, if the site specific direction of ground water flow or the specific plume configuration is known, only the wells within 1/2 mile down-gradient in a 90 degree arc from the source of contamination, and the population they serve, will be used to estimate the population potentially at risk. If the direction of ground water flow is strongly suspected, either from prominent topographical features (such as steep hillsides or nearby surface water bodies), significant water withdrawal (large capacity wells) or from nearby studies, the wells within a 1/2 mile radius in a 180 degree arc from the source of contamination will be used. Finally, if the direction of ground water flow is neither known nor suspected, all wells within a one-half mile radius of the site will be used to estimate the population potentially at risk. If a public water supply system is supplied by a ground water well network within the appropriate 1/2 mile radius arcs described above, the actual population served by the water supply system is included in scoring. Only those homes using ground water for drinking water are included: if some or all of the homes are supplied by a public drinking water system, these homes are not included in the counts unless the public well(s) are within the 1/2 mile radius.

If there is a discontinuity (such as a perennial stream or lake which intersects the useable aquifer) which should impede or alter the ground water flow, truncate the radius at the discontinuity and do not include population beyond the discontinuity in the estimate.

4.1.5.2 Surface Water

In the case of surface water, population at risk accounts for the possibility that there may be human exposure either through drinking water supplies taken from surface waters, through direct contact via bathing, boating, or water skiing, or through fish ingestion. The potential zone of influence of the contamination site has been extended beyond the 1/2 mile radius circle around the site. If a surface water body falls within the 1/2 mile radius of a contamination site, extend the area of influence five miles downstream for a river or stream. For a lake, the contamination extension is identified by drawing a 1/2 mile arc from the point on the lakeshore closest to the contamination site and including all shoreline contained in the arc. Note that the 1/2 mile arc may also include homes on the opposite shore. The population 1/2 mile inland of these extended limits is included in the potential zone of effect for the population at body contact risk and fish ingestion risk but not for population at drinking water risk unless a water intake is within the original 1/2 mile radius of the site. The population within the 1/2 mile extension is included because this is within a reasonable walking distance of the water body. If a public water supply system is supplied by a surface water intake within the original 1/2 mile radius of the site, the actual population served by the water supply system is used in scoring.

The number of surface water potable water intakes is relatively small in Michigan, although some of these intakes supply the largest public water supply systems in the State (greater Detroit area, Grand Rapids). When scoring for public drinking water supplies, the actual population served by the water supply system is used (when the water intake is within the zone of influence) and points are assigned according to population size.

When scoring for potential body contact, points are assigned according to the means that the population uses to gain access to the bathing activity. Thus, a population which may be exposed at a public beach is estimated by the number of vehicle parking spaces provided at the beach parking facility. The resident shoreline bathing population is estimated directly from the number of homes along the shoreline within the zone of influence. The population which may become exposed via fish ingestion obtain access from shoreline homes, public access sites and bridges over streams or rivers. The population score is based on the number of homes or number of vehicles at these access points.

For fish ingestion risk, apply the population estimates described above for public access sites and shoreline population.

4.1.5.3 Air

For the air compartment, the entire population within the one-half mile radius of the site must be scored because all may, at one time or another, be exposed to a contaminant plume which shifts with every change in wind direction and which may also be episodic in nature (SAB, 1988). The prevailing wind direction is not considered because these data are seldom available for a site and the rest of the population in the non-prevailing wind direction will still periodically be exposed. The target area is a circle of 1/2 mile radius when the site is small. For large sites or where there has been surface migration and deposition of contaminants, the target area is a zone 1/2 mile wide surrounding the furthest known extent of contamination.

4.1.6 Environmental Contamination Assessed In Existing Exposure

Many staff and public commenters (Carpenter, 1988b) noted an apparent bias in the 1983 model toward risk to public health at the expense of environmental risk. Committee review revealed that the problem was due to under evaluation of environmental resources in the model and the lack of consideration given to parmeters such as aquifers not used for drinking water, irrigation water, and interference in use of nearby parklands. The committee found, however, that the evaluation methods for human risk were appropriate (SASCOM, 1988) and that some emphasis on human risk was necessary. It concluded that improvement in environmental risk estimation was needed and this is the purpose behind expansion of the existing exposure assessment described below.

Many contamination sites in metropolitan areas where drinking water is supplied have resulted in ground water contamination (Washout Laundry, Herman Radio Tower, Pool County Area, GW Contamination Penninsula Township, Boardman Lake, Bay City Middlegrounds, and Douglas Components sites, to name a few, in Appendix B). These sites end up with low site scores because both the population at risk value and existing exposure scores are reduced to zero when there are no vicinity wells drawing from the contaminated aquifer. Similarly, few surface water supply systems are within one - half mile of contamination sites with the result that seldom is surface water existing exposure scored. In the air compartment, the only existing exposure parameter ever scored is the odor portion which makes up a minor portion of the available existing exposure score. In all environmental compartments, no existing exposure score is given to the contaminated environmental resource itself.

A review of 1983 SAS scoring revealed that existing exposure is more frequently scored in ground water than surface water simply because wells are more frequently installed and sampled. Surface water or sediments are seldom sampled even if intakes are nearby. Thus, there is a bias in the site investigation approach toward ground water with surface water, or occasionally air, being sampled only after a ground water risk has been established. While approximately one - half of the state population obtains its water from surface water (Bedell, 1977 and US Geological Survey, 1980), many of these intakes are offshore in the Great Lakes, often more than one - quarter mile, with the result that surface water population at risk is seldom scored.

The intent of the existing exposure category is to assess the extent to which people or the environment, in the vicinity of a contamination site, have been exposed to a known release from containment structures at the site. It is scored only when environmental resource contamination is documented by direct chemical analysis. In the RSAS, secondary uses such as irrigation water and inherent resource value has been added so that if a resource is not used by humans, a somewhat lesser value is scored for the contaminated resource. Thus, contaminated ground or surface waters not used as drinking water sources are now scored.

4.1.6.1 Ground Water

In the ground water compartment, the magnitude of the existing exposure hazard is a function of the contaminant concentration in ground water and the degree of exposure. It is assumed that hazard increases as the value of these parameters increases. The level of hazard is determined by the actual exposure concentration and the extent to which this concentration equals or exceeds known background conditions. The degree of exposure depends upon the nature of the receptor (whether the environment, agricultural resources or human populations have been exposed) and the size of the receptor population.

Each contaminant, its concentration, and the nature of the sample is identified. If the contaminant has been detected at more than one sampling location or in more than one sample from a sampling location, use the greatest concentration detected. A background concentration is determined according to the hierarchy 1) site vicinity values, 2) statewide mean values, or 3) assumed values. Site vicinity values are those which have been determined from samples collected at or near the site up-gradient from the contaminated area or otherwise known to not be contaminated. If a contaminant is documented off-site in an up-gradient direction which indicates that there is contamination not attributable to the site and it is believed this is typical of the area, this concentration becomes the background concentration. Care must be taken that contaminant mounding is not occurring at the site before defining up-gradient concentrations as background levels. Statewide mean values are applicable to inorganic compounds which may generally be present in ambient ground water while organic compounds are considered using assumed values of zero.

The background level is subtracted from the contaminant concentration to derive the exposure concentration for each contaminant. The appropriate concentration or chemical exposure factor is selected from Table 4.20 while the appropriate environmental exposure factor (either a monitoring well value or irrigation/livestock value plus a human population value) is selected from Table 4.21. The chemical exposure factor is multiplied by the environmental exposure factor for each chemical and the individual chemical scores are totaled to derive the ground water existing exposure score.

There is no distinction in number of impacted wells in both the monitoring or irrigation/livestock well categories. If more than one well is impacted, the base value of 7.5 for an impacted water table, 12.5 for an artesian aquifer, or 5.0 for irrigation/livestock wells is applied.

There is a distinction between the water table and an artesian aquifer when considering contaminated monitoring wells. The water table

Table 4.20 Ground Water and Surface Water Compartments Chemical Concentration Exposure Factor

Concentration Above Background Levels (ppb)	Chemical Exposure Factor
<10	2
10 - 50	4
51 - 500	6
501 - 1000	8
>1000	10

Table 4.21 Ground Water Compartment Environmental Exposure Factor

Parameter	Factor
Monitoring Well	
Water Table Impact	7.5
Artesian Aquifer Impact	12.5
OR	
Livestock/Irrigation Well	5
PLUS	
Drinking Water Well(s)	
Population Served	
1 - 24	15
25 - 100	18
101 - 1000	20
1001 - 10,000	22
>10,000	25

includes near surface, unprotected aquifers as well as perched, unprotected water lenses. An artesian aquifer is intended to include protected useable aquifers. The key requirement is that the artesian aquifer is protected by an impervious layer (such as clay or shale). However, if a contaminated monitoring well is completed in the water table and nearby (within one-half mile of the contamination site) private potable water supply wells are known to be completed in the same layer, apply the base artesian aquifer value of 12.5 instead of 7.5 for the water table.

If a permanent, uncontaminated water supply system has been installed and the contaminated system has been taken off-line or plugged, the population served by the new system is not included in the population estimates. The aquifer which served the abandoned well is still considered contaminated and should be scored using the monitoring well approach.

Note that the total existing exposure score is not to exceed 300 points if both irrigation/livestock wells and human drinking water wells are impacted. If human drinking water wells are exclusively impacted, the maximum score is 250 points. If only monitoring well contamination is known at the site, the maximum existing exposure score is either 75 points if a surficial or water table aquifer is impacted or 125 points if an artesian or protected aquifer is impacted.

4.1.6.2 Surface Water

In the surface water compartment, Human exposure is scored when a surface water potable water supply intake has been contaminated so that contaminants may be entering the water supply system. Environmental existing exposure is scored only when surface water or fish contamination is documented by direct chemical analysis and the contamination is attributed to or strongly correlated with a site. Environmental surface water contamination may be documented by either surface water or sediment sample results. This equates to a determination that there has been a known release from the containment structure(s) at the site which has resulted in some level of contamination.

The magnitude of the existing exposure hazard is a function of the contaminant concentration in a water supply system, surface water or aquatic sediments, or whether a fish consumption advisory has been issued, and the degree of exposure. It is assumed that hazard increases as the value of these parameters increases. The level of hazard is determined by the actual exposure concentration and the extent to which this concentration equals or exceeds known background conditions. The degree of exposure depends upon the nature of the receptor (whether the environment, agriculture or human populations have been exposed) and the size of the receptor population. If a fish consumption advisory has been issued, the hazard is related to the nature of the advisory and the number of fish species affected.

Each contaminant and its concentration is identified. The background concentration is determined according to the hierarchy 1) up-gradient, up-stream site vicinity values, 2) statewide mean values or 3) assumed values. Site vicinity values are those which have been determined from samples collected at or near the site up-gradient or up-stream from the contaminated area or known release point or are otherwise known to not be contaminated. Statewide mean values are applicable to inorganic compounds which may generally be present in ambient surface water while organic compounds are considered using assumed zero background values.

The background level is subtracted from the contaminant concentration to derive the exposure concentration for each contaminant and the appropriate chemical exposure factor is selected from Table 4.20. select the appropriate environmental exposure factor (surface water or sediment concentration value or irrigation/livestock value and human population values) from Table 4.22. The chemical exposure factor is multiplied by the environmental exposure factor for each chemical and the individual chemical scores are totaled to derive the surface water subtotal.

If a contaminated water intake has been replaced so that the distribution system is no longer receiving contaminated water, it should not be scored as drinking water existing exposure. If a continuous release is occurring, the surface water body is still considered contaminated and should be scored via the contaminated water, sediments or fish concentration approach.

Table 4.22 Surface Water Compartment Environmental Exposure Factor

Parameter	Factor
Surface Water/Sediment	5
<u>OR</u>	
Irrigation/Livestock	5
<u>PLUS</u>	
Drinking Water Population Served	
1 - 24	15
25 - 100	18
101 - 1000	20
1001 - 10,000	22
> 10,000	25

Fish consumption risk is based upon the concentration of contaminants in fish tissue which are known to be involved at the contamination site and a release to surface water is known or strongly suspected. The tissue concentration factor is obtained from Table 4.23 and multiplied by the fish consumption population at risk factor in Table 4.24 to obtain the fish consumption score. If a fish consumption advisory has been issued for the affected surface water body, the advisory scoring procedure in Table 4.25 is applied to obtain the fish consumption score. This score is added to the surface water subtotal to derive the surface water existing exposure score.

Note that the total existing exposure score is not to exceed 350 points if all categories apply. If human drinking water supplies are affected, the maximum score is 100 points. If the drinking water supply category is scored, the water or sediment contamination is not scored. To determine whether a drinking water supply intake is within the area of influence of a contaminant release to surface water, apply the zone of influence procedures described in Population at Risk.

4.1.6.3 Air

In the air compartment, the existing exposure category takes into consideration existing emissions to the ambient air on site and existing exposure to the human population in the target area surrounding the site. Odors or concentrations measured on-site indicate that the ambient air is contaminated. While dispersion reduces that ambient air concentration at a nearby downwind receptor, it does not eliminate

Table 4.23 Surface Water Compartment Fish Tissue Concentration Factor

Concentration (ppb)	Factor
<10	4
11-500	6
51-1000	8
>1000	10

Table 4.24 Surface Water Compartment Population at Fish Ingestion Hazard Factor

Population Size	Factor
1-50	1
50-200	3
>200	5

Table 4.25 Surface Water Compartment Fish Contaminant Advisory Factor

Type of Advisory	Score	
	one species	two or more species
No Advisory Issued	0	0
Restrict Consumption[1]	20	35
No Consumption[2]	35	50

[1] Restrict consumption to no more than one meal per week. Children, women who are pregnant, nursing or expect to bear children should not eat any fish.

[2] No one should consume the species listed in the advisory.

exposure to the contaminants. The degree of adjacent receptor exposure depends upon the concentrations found at the site and the distance from the area of contamination to the receptor.

Existing exposure also considers surface deposition of contaminants off-site, especially non-volatile organic contaminants, as an indication of existing exposure. Such off-site deposition most likely resulted from airborne transport from the site or vehicle track-out and may be subject to further dispersion by wind or vehicle activity. This category provides an evaluation of the relative risk due to ambient concentrations at the site, at the property line, or off-site at a receptor such as a residence. It should be noted that on-site concentration has intentionally been allocated a higher score than off-site concentration because of the practicalities of air sampling and site scoring procedures.

The overall scoring procedure requires on-site concentration data as minimum air data. Air concentration data at the property line or at receptors are rarely obtained or available in the course of remedial investigations. Property line or off-site data, if available, result in a separate score which is added to the score for on-site concentration.

Three subcategories of existing exposure, on-site concentration, off-site concentration and off-site deposition have been developed.

On-Site Concentrations

The on-site concentrations subcategory calculates a relative risk for deterioration of the on-site ambient air and the probability of migration of volatile contaminants from the site. If on-site compound-specific ambient air data are available, data that have been taken at or near the actual area of contamination (ie., by lagoons, stockpiles, barrels) should be used. The volatile organic compounds (VOC) concentrations of all the compounds found at the site are added to obtain the total VOC's in parts per million (ppm). If compound-specific concentration data are not available, a portable photoionization detector (PID) should be used to obtain total volatile contaminant concentrations at the breathing zone at or near the actual area of contamination.

The approximate distance from the point at which the highest reading was obtained to the nearest site property line needs to be estimated to perform on-site concentration scoring. Figure 4.10 illustrates the property line and waste relationships considered in on-site scoring.

The on-site concentration factor corresponding to the appropriate on-site air concentration and distance to the nearest property line should be selected from Table 4.26. Using the population size derived in population at risk, the surrounding population factor is obtained from Table 4.27. The on-site concentration score is obtained by multiplying the on-site concentration factor by the surrounding population factor.

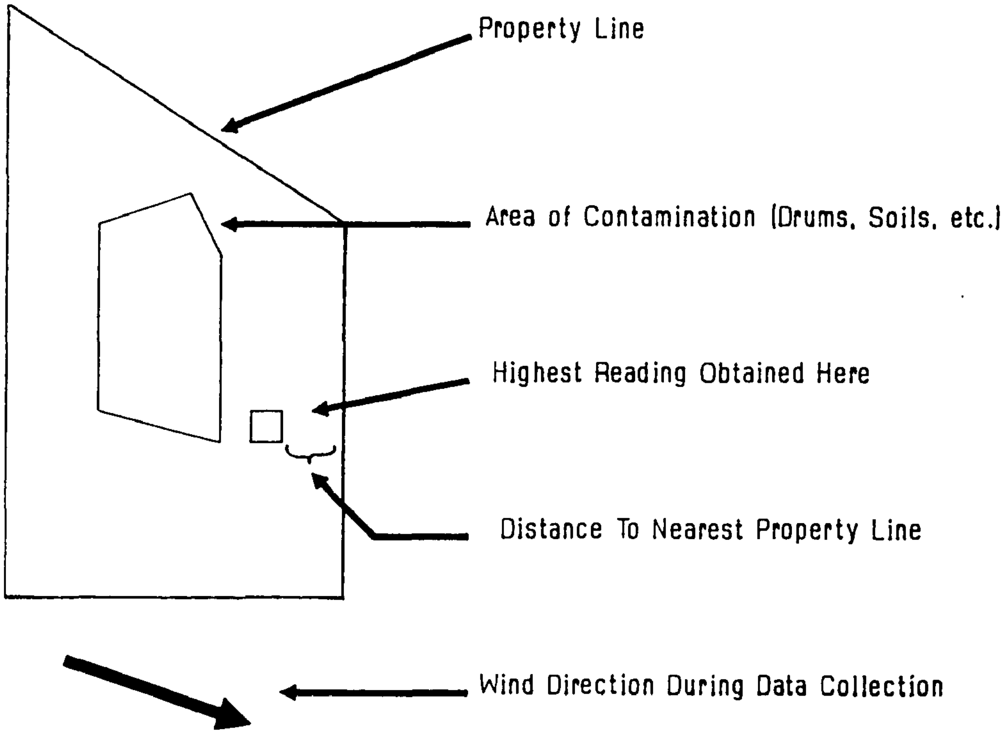


Figure 4.10 Property Line and Waste Relationships for On-Site Concentration Scoring

Table 4.26 Distance to Nearest Property Line Index for On-Site Concentration Scoring in the Air Compartment

Onsite concentration (ppm total VOCs)	Distance to nearest property line		
	0-100 ft.	101-500 ft.	>500 ft.
Non detect	0	0	0
< 10	8	7	6
10-25	9	8	7
> 25	10	9	8

Table 4.27 Air Compartment Surrounding Population Factor for Existing Exposure Scoring

Surrounding Population	Factor
1 - 12	10
13 - 24	12
25 - 100	14
101 - 250	16
251 - 500	18
501 - 750	20
751 - 1,000	22
1,001 - 3,000	23
3,001 - 10,000	24
>10,100	25

Off-Site Concentrations

The off-site concentrations subcategory derives a relative risk for deterioration of off-site ambient air, either at the property line or at receptors. It is scored if ambient air monitoring data or odors are detected at the site property line or at a receptor. Furthermore, if an odor or specific compound is detected at the site boundary or at an off-site residence, the on-site concentration score is awarded the highest value.

There are two options available for scoring off-site concentration: measured concentrations or odors. Measured concentrations are further divided into compound specific or total VOC methods.

If compound specific concentration data are available, each compound and its highest ambient air concentration must be identified. The risk-assessed ambient air values for all of the carcinogens present are obtained from Table 4.28 and the one percent of the Threshold Limit Value (TLV) for all of the non-carcinogens present are obtained from ACGIH (1988). The following ratio is calculated for each compound

$$\frac{\text{Ambient concentration at property line or receptor}}{\text{Conc.of 1\% TLV or risk-assessed value}}$$

Table 4.28 Air Compartment Carcinogen Contaminants and Risk Assessed Concentrations

Contaminant Name	Risk-assessed value (ug/m3)
acetaldehyde	0.4
acrylonitrile	0.01
o-anisidine hydrochloride	0.04
arsenic	2.3E-04
benzene	0.14
benzo(a)pyrene	3.0E-04
bis(2-chloroethyl)ether	0.003
1,3-butadiene	0.003
1,2-butylene oxide	1.2
cadmium	5.6E-04
carbon tetrachloride	0.04
chlorinated paraffins (C10-C12;60% chlorine)	0.03
chlorodibromomethane	0.04
chloroform	0.04
3-chloro-2-methylpropene	0.03
1-chloro-2-nitrobenzene	0.21
chromium VI	8.3E-05
DDT	0.003
dichlorobenzidine	0.002
diethylhexyl phthalate	0.23
dimethylvinyl chloride	0.008
1,4-dioxane	0.18
epichlorohydrin	0.8
ethyl acrylate	0.07
ethylene dichloride	0.09
ethylene oxide	0.03
formaldehyde	0.09
hexachlorobenzene	0.002
hydrazine	0.003
methyl chloride	1.6
MBOCA	0.03
methylene chloride	1.0
2-naphthylamine	1.3E-04
PCB (Aroclor 1260)	0.001
propylene oxide	1.6
2,3,7,8-TCDD	2.3E-08
1,1,1,2-tetrachloroethane	0.07
1,1,2,2-tetrachloroethane	0.02
tetrachloroethylene	1.7
toluene diisocyanate	0.03
toxaphene	0.003
trichloroethylene	0.6
TRIS	0.002
vinyl chloride	0.4
2,6-xylidine	0.78

and the appropriate score for the ratio of each compound is selected from Table 4.29. The surrounding population factor is obtained from Table 4.27 and multiplied by the highest ratio score obtained above.

If only total VOC data are available, the appropriate score for the highest VOC level measured by a PID taken at the site property line or at receptors is selected from Table 4.30. The surrounding population factor is obtained from Table 4.27 and multiplied by the highest score obtained from Table 4.30.

To evaluate odors, the scores appropriate to the odor levels detected at various points along the site property line or receptors are obtained from Table 4.31. The surrounding population factor for the site is then obtained from Table 4.27 and multiplied by the highest score obtained from Table 4.31.

Off-Site Deposition

Off-site deposition, primarily evident in cases of non-volatile compounds associated with dust particles, is an indication of airborne transport of the contaminants. Concentrations of such compounds may also have resulted from vehicle track-out and may be further dispersed by wind or vehicle activity. In either case, the presence of these contaminants off-site indicates past or continuing air compartment exposure.

Table 4.29 Index for Compound-Specific Concentrations at Site Boundary or at Receptors

Compound Concentration: Ratio of measured conc./[RAV or 1%TLV]	Index
None detected	0
Less than 10 %	3
10 % to 49 %	4
50 % to 100 %	5
More than 100%	6

Table 4.30 Index for Concentrations Detected by Hand-Held Photoionization Detection Instruments at the Site Boundary or Nearby Receptors

Total VOC Measured concentration (HNU or OVA)	Index
None detected	0
Less than 1 ppm	4
1 - 5 ppm	5
More than 5 ppm	6

Table 4.31 Air Compartment Detected Odors Index

Odor Description	Score
No odors detected	0
Odors detected	4
Moderate odors	5
Obnoxious/chemical-specific odors	6

The location of off-site contaminant deposition should be determined by analyzing surface soil concentration data. Using Table 4.32, the appropriate score for each circumstance or location of off-site deposition is selected. If off-site deposits have been found in more than one location, use the highest score. The surrounding population factor for the site is selected from Table 4.27 and multiplied by the highest score obtained from Table 4.32.

4.1.7 Ground Water Target Scoring

In the ground water compartment, migration prevention is assessed by evaluating the ability of the overburden to prevent contaminant transport to the useable aquifer. The scoring criteria for the ground water compartment assess the relative ability of the subsurface geological material to minimize or prevent a contaminant from migrating to a useable aquifer. Both the depth to the useable aquifer and soil permeability are considered in evaluation of the overlying soils. The permeability and thickness of the useable aquifer are used to assess the impact on aquifer(s) and the potential for further contaminant migration.

The useable aquifer is defined in the Michigan Safe Drinking Water Act (Act 399 of the Public Acts of 1976) as a water bearing geological formation which is capable of providing a potable water supply and extends below a depth of 25 feet. If a shallow aquifer does not meet these useable aquifer conditions but a deeper aquifer exists which does, the shallow aquifer should not be scored for potential exposure. In

Table 4.32 Air Compartment Off-Site Deposition Index

Location of Off-site Deposition	Index
Unused industrial land	1
Unused land (no residence or farm)	2
Paved road or paved shoulders	3
Gravel road or gravel shoulders	4
Crop/pasture land	5
Yard/driveway of residence	6

RSAS, however, this definition is to be applied on a regional aquifer use basis. For example, there are some areas of the State (for example Monitor and Williams townships of Bay Co.) where conditions for a legal well cannot be met because a deeper aquifer does not contain potable water. The regional use dictates that the shallow aquifer is the only aquifer which can be used and therefore potential exposure would be scored for this aquifer. Therefore, if water wells have been completed in a shallow aquifer (less than 25 feet in depth) and are within the 1/2 mile radius area defined in population at risk, the aquifer should be scored.

Depth to the useable aquifer (or the thickness of the overlying soils) is measured vertically from the lowest point of contaminant containment to the highest point of the useable aquifer, including the containment layer above the useable aquifer (usually clay) if one exists. The earth materials, thickness intervals, and scoring values for all overlying soils between the useable aquifer and the containment structure have been revised as shown in Figure 4.11. If the earth materials of the overlying soils are variable or layered and several layers are evident, thickness weighted averages for each material are calculated and summed for the score.

Contaminants are known to persist in the ground water for longer time periods than in air or surface water (Rosenblatt, et al., 1985, and Freeze and Cherry, 1985). Therefore, characteristics which demonstrate the capability of the useable aquifer to provide future water supplies are considered when evaluating environmental resource value. These

EARTH MATERIAL CATEGORY	I	II	III	IV	V	VI
Glacial Deposits	Gravel, Medium to Coarse Sand	Fine to very Fine Sand	Sand with <15% Clay &/or Silt	Sand with >15% but <50% Clay &/or Silt	Clay or Silt with <50% Sand	Clay
Consolidated Rock	Cavernous or Fractured Limestone, Evaporites, Basalt Lava, Fault Zones	Fractured Igneous and Metamorphic (except lava), Poorly Cemented Sandstone	Moderately Cemented Sandstone, Fractured Shale	Well Cemented Sandstone	Siltstone	Unfractured Shale, Igneous and Metamorphic Rock
Representative (cm/sec) Permeability (gpd/ft^2)	>10E-2 >200	10E-2 to 10E-4 200 to 2	10E-4 to 10E-5 2 to 0.2	10E-5 to 10E-6 0.2 to 0.02	10E-6 to 10E-7 0.2 to 0.002	<10E-7 <0.002

RATING MATRIX

Overlying Soils Thickness (ft)	I	II	III	IV	V	VI
>100	85	60	30	10	20	10
60-100	90	70	35	15	40	20
30-60	94	80	40	20	10	30
15-30	96	85	70	30	20	40
3-15	98	90	80	60	30	10
<3	100	95	90	80	70	50

Figure 4.11 Overlying Soils Scoring Matrix

characteristics are the thickness of the useable aquifer and the potential yield which is reflected by the earth material or permeability of the useable aquifer zone.

The depth intervals and earth materials of all aquifers and intervening non-aquifer materials are evaluated according to the criteria in Figure 4.12 and an earth material score is determined for each interval using the thickness and earth material classifications. In this manner, a weighted average score is derived for the entire zone beneath the overlying soils. Add the weighted scores to derive the total score for the useable aquifer.

4.1.8 Surface Water Target Scoring

In the surface water compartment, migration prevention is assessed by determining the proximity of the contamination site to surface water resources, the land slope to those resources and the probability that flooding of the site or intervening topography will occur. Only the distance to the nearest surface water body and intervening land slope is considered. No provision is made for soil structure or type nor for interflow. The evaluation of distance to surface water and land slope, as well as flood potential remain unchanged from the 1983 SAS and will not be presented here.

EARTH MATERIAL CATEGORY				
Glacial Deposits	Gravel Sand & Gravel	Fine to very Fine Sand	Sand with <15% Clay	Clay with <50% Sand
Consolidated Rock	Cavernous or Fractured Sedimentary Rock, Fault Zones, Basalt Lava	Fractured Igneous or Metamorphic Rock, Poorly Cemented Sandstone	Moderately to Well Cemented Sandstone, Fractured Shale	Siltstone, Unfractured Shale, or other Impervious Rock
Representative (cm/sec) Permeability (gpd/ft^2)	>10E-2 >200	10E-2 to 10E-4 200 to 2	10E-4 to 10E-6 2 to 0.02	<10E-6 <0.02

RATING MATRIX

	>100	100	60	40	20
USEABLE	50-100	80	50	30	15
AQUIFER	10-50	60	40	20	10
THICKNESS	3-10	40	30	10	5
(feet)	<3	20	10	5	1

Figure 4.12 Useable Aquifer Scoring Matrix

Special Condition

If the decision has been made that surface water bodies cannot be contaminated by overland flow due to a barrier between the site and the water body, or the site being at a lower elevation than the water body, the compartment may still be scored for potential contamination of surface water resources by contaminated ground water. The potential for surface water contamination by a ground water release exists only if ground water is known to be contaminated. Unless there is documented ground water contamination (and, therefore, existing exposure has been scored in the ground water compartment), contaminant containment must be assumed to be adequate and the potential of surface water contamination by contaminated ground water cannot be scored. The release potential and environmental fate factor values for this situation are derived in Chapter 4.1.4.3. When scoring this special condition, do not score surface water existing exposure or the site slope or flood potential components of the targets section.

5.0 Results and Discussion: Model Evaluation

5.1 Changes in Descriptive Statistics

Examination of the change in mean total site and compartment scores and their ranges, shown in Table 5.1, illustrates the increase in variability and discrimination of the RSAS over the 83 SAS. For example, the total site score increased from 632 in the 83 SAS to 1087 in the RSAS. This represents an increase in the ability to discriminate among sites because, with a greater range of site scores available, the chance that two sites could obtain the same site score is reduced and the chance of separation among site scores is increased. This is further illustrated by the minimum and maximum scores where the range of total site score increased from 908 in the 83 SAS to 1760 in the RSAS. More of the total points available are utilized in the RSAS (2028 of 2888) than in the 83 SAS (1058 of 2000) where the RSAS came within 860 points of the maximum 2888 points available opposed to 942 of 2000 available in the 83 SAS.

At the time of initiation of this study, 1058 was the highest site score obtained with the 83 SAS indicating that it was among the most extreme or severe sites in the State. This shows that 47% of the points available in the 83 SAS were not utilized by the most significant site analyzed by the model and that discriminatory power of the model was not used. In contrast, only 30% of the Revised SAS model remained unused by the same severe site, which indicates that the power of discrimination by the model has increased. That 30% of the total available model score

Table 5.1 Descriptive Statistics for Total Site Score and Individual Compartments in the 1983 Site Assessment System and the Revised Site Assessment System

	Parameter	Mean	Std Dev	Minimum	Maximum
1983 SAS					
	Screen	8	3	1	14
	Total Site Score	632	242	150	1058
	Chemical Hazard	273	178	0	525
	Ground Water	242	124	0	466
	Surface Water	188	124	0	435
	Air	24	72	0	370
	Direct Contact	76	84	0	261
RSAS					
	Revised Screen	30	7	12	43
	Total Site Score	1087	561	268	2028
	Chemical Hazard	622	517	15	1300
	Ground Water	319	171	0	686
	Surface Water	275	129	0	620
	Air	44	88	0	376

remains, allows for detection of a site more severe than is currently known.

Similarly, all mean compartment scores and their ranges increased, indicating that discrimination and utilization of point scales had increased. The increases in the ground water, surface water, and air compartment mean scores were 32, 46, and 83 percent respectively, illustrating the degree of changes that occurred in the compartments. One curious effect occurred in the air compartment. While the mean score increased 20 points from 24 to 44 points, the range in scores did not significantly change remaining at 0 to 370 in the 83 SAS and 0 to 376 in the Revised SAS. This further indicates that the discrimination has increased in the Revised SAS since the larger mean within the same score range could occur only by more sites receiving higher scores. The air compartment was the only compartment in which the maximum score did not significantly increase, indicating that the Revised SAS still may not evaluate the potential for air contamination at contamination sites.

Comparison of the two screening systems is not appropriate since the changes between the two systems is so pronounced. The conceptual design of the revised screen, as well as the size of the potential score range, is so different that meaningful comparison is impossible. It is interesting to note in the revised screen, however, that the minimum score obtained was 12 of a possible 50 points. This might indicate that the revised screen is too sensitive and utilization of low site scores is lost. It could also be a function of the relatively small test site universe and indicate that very low risk sites were inadvertently overlooked in test site selection.

5.2 Compartment Dominance

Table 5.2 shows the stepwise regression analysis for the 1983 SAS and the revised SAS. The multiple R value shows that the correlation between the chemical hazard score and the total site score is high and the compartment accounts for the majority of the site score. The adjusted R^2 values (goodness of fit adjusted to the size of the test population) indicate that the 1983 SAS data are moderately well represented by the chemical hazard score while the RSAS data are quite well represented. In both models, chemical hazard is the dominant compartment although the dominance is much stronger in the revised model than in the 1983 SAS. Examination of the standard error values reveals that the standard error is lower for the 83 SAS than it is for the RSAS. This implies that the RSAS chemical hazard data are less reliable than the 83 SAS data. However, the greater variability in the data reflect the difference in score ranges between the two models where the maximum score available in the 83 SAS is 450 points while in the RSAS it is 1300 points.

The increase in dominance by the RSAS chemical hazard score also reflects its increase in emphasis in the model structure where the point total is enlarged and made more equivalent to the environmental compartments. The increase in dominance of site score by chemical hazard is appropriate because contamination is a function of contaminant

Table 5.2 Stepwise Regression Analyses of Compartment Contribution to Total Site Score in the 1983 Site Assessment System and the Revised Site Assessment System

	Step	Variable Added	Multiple R	R^2	Adjusted R^2	SE
1983 SAS						
	1	Chem. Hazard	0.87122	0.75902	0.75400	119.8
	2	Surface Water	0.93700	0.87797	0.87277	86.2
	3	Ground Water	0.98574	0.97169	0.96985	41.9
	4	Air	0.99035	0.98080	0.97909	34.9
	5	Direct Contact	0.99090	0.98187	0.97981	34.3
RSAS						
	1	Chem. Hazard	0.96020	0.92199	0.9203	158.3
	2	Ground Water	0.97907	0.95857	0.95861	116.6
	3	Surface Water	0.99372	0.98748	0.98666	64.8
	4	Air	0.99416	0.98835	0.98732	63.2

severity and quantity on site. In another study using scatterplot cluster analysis, Gruben (1988) concluded that the 1983 SAS score was dominated by the ground water compartment score. While her site universe was larger (354 sites versus 50 in the present study) the conclusion was not valid for the kind of statistic utilized. Scatterplot analysis identifies data trends but does not demonstrate statistical correlation. In the Gruben study (1988), scatterplot analysis noted the coincidence of high ground water compartment scores with total site score but did not evaluate the relationship between the two scores. Also in that study, the chemical hazard score scatterplot revealed the same, although somewhat lesser, coincidence of high compartment score with high total site score. However, visual analysis of the data also shows that when a high site score is obtained, the chemical hazard score is usually at or near the maximum points available. Thus, the chemical hazard score is the dominant compartment score and this has been emphasized further in the RSAS.

While the chemical hazard compartment dominated both the 1983 SAS and RSAS scores, the second most important compartment was different. In the 1983 SAS, the surface water compartment was found to be the second most important contributor to total site score by the stepwise regression analysis while the ground water compartment was second in analysis of the RSAS. This difference between the compartments is relatively unimportant because of the overall dominance of the multiple R value by the chemical hazard compartment and the small additional contributions by the other compartments. In the 83 SAS, the contribution to total site score by the surface water compartment is greater than that of the ground water compartment. In the RSAS, the small contributions by the two compartment are almost identical indicating that the contributions of the two compartments are almost identical.

In both models, however, the contribution of the air compartment is considerably smaller than the other compartments. This implies that the changes in the RSAS model structure to allow the air compartment to contribute more to overall site assessment did not result in any significant increase in importance of the compartment. Examination of individual site scores reveals that this is not the case, however. As in the 1983 SAS, few, although more sites were scored in the RSAS air compartment. When the air compartment was scored, the compartment score relative to the other environmental compartments was more significant and the compartment did contribute to the total site score.

Gruben (1988) implied and Carpenter and Warner (1988) stated that with such clear dominance of the site score by a single compartment, the analyses of the other compartments might be unnecessary. It was reasoned that scoring the other compartments when they appeared to contribute little to overall site score did not add to the statistical analysis of the site. Statistically this might be true but discrimination among sites would be lost if the other compartments were dropped from the model. The purpose of the model is to discriminate among sites and this is accomplished by the range in site scores available and the evaluation of a variety of parameters. Regression and scatterplot analyses are trend analyses and miss a vital point in contamination site evaluation. The severity of a site depends upon its existing and potential contamination of environmetal media. That is, with some level of hazard present, the greater the extent of contamination and the threat for further contamination, the more critical a site is. Thus a site where there is surface water as well as ground water contamination is more severe than one where there is only ground water contamination. Elimination of compartments because their contribution or explanation of site score is minimal merely reduces discrimination and interpretation of severity among sites.

5.3 Comparison Of Site Rankings 83 Screen, 83SAS, R Screen, and RSAS

A summary of site rankings resulting from the 83 Screen, 83 SAS, R Screen, and RSAS is presented in Table 5.3. Of the 50 sites scored in this study, Site 7 was identified by the 83 SAS, R Screen, and RSAS as the highest ranked site and highest scored site while the 83 Screen placed Site 7 in a seven-way tie for seventh rank. The site receiving the highest score and rank in the 83 Screen (Site 2) received a rank of 25 in the 83 SAS, 11 in the R Screen, and 36 in RSAS. While there is no indication that one system is more "right" than another, this illustrates the principal need of the screening and scoring systems: consistency of relative site importance. These standards are explored below.

Table 5.3 **Summary of Test Sites Rankings and Scores Produced by each Model**

	83 Screen		83 SAS		RSAS Screen		RSAS Score	
RANK	Site#	Score	Site#	Score	Site#	Score	Site#	Score
1	2	14	7	1058	7	43	7	2028
2	22	12	45	983	8	43	8	1991
3	26	12	46	969	6	42	26	1926
4	5	11	8	949	38	41	37	1910
5	20	11	24	891	49	41	11	1836
6	30	11	49	886	3	40	9	1771
7	1	10	43	885	32	40	29	1771
8	4	10	23	878	29	39	30	1754
9	6	10	37	868	16	37	27	1748
10	7	10	50	850	45	36	49	1741
11	8	10	6	847	2	35	28	1675
12	11	10	44	845	11	35	24	1661
13	27	10	48	838	43	35	16	1643
14	9	9	29	837	46	35	21	1639
15	24	9	30	826	9	34	44	1618
16	29	9	3	820	37	34	50	1583
17	32	9	21	796	48	34	43	1542
18	33	9	47	789	50	33	6	1404
19	43	9	20	722	4	32	3	1333
20	47	9	26	740	47	32	46	1308
21	48	9	11	734	24	31	39	1287
22	3	8	22	734	30	31	45	1042
23	10	8	9	730	33	31	23	1026
24	18	8	39	704	41	31	20	984
25	28	8	2	687	1	30	25	984
26	41	8	33	683	22	30	22	984
27	44	8	32	667	44	30	12	908
28	46	8	41	606	21	29	10	809
29	34	7	42	580	26	29	41	766
30	37	7	25	573	28	29	32	750
31	39	7	14	563	31	29	34	713
32	45	7	31	530	14	28	1	691
33	49	7	15	517	5	27	47	671
34	12	6	5	510	20	27	42	605
35	15	6	28	510	13	26	2	596
36	16	6	10	504	18	26	48	582
37	50	6	16	482	23	26	15	570
38	14	5	18	441	10	24	31	569
39	21	5	1	440	12	24	4	561
40	25	5	27	398	17	24	18	542
41	38	5	13	389	27	24	5	521
42	17	4	19	330	39	23	33	516
43	23	4	36	300	15	21	13	501
44	13	3	4	289	34	21	36	427
45	31	3	35	280	42	21	14	421
46	36	3	17	260	19	20	35	417
47	42	3	12	243	36	18	38	411
48	19	2	38	233	25	17	40	358
49	35	2	40	195	40	17	17	296
50	40	1	34	150	35	12	19	268

5.4 Low Correlation Between The 83 Screen And The 1983 SAS Score

An analysis of the correlation between the 1983 Screening System and the 1983 SAS revealed that the screening system did not predict the final magnitude of the site score nor a site's relative rank (Carpenter, 1988b and Carpenter and Warner, 1988). When the 50 sites evaluated in the current study are ranked by both systems and broken into groups of 10, only site 7 was ranked in the top 10 by both systems. Two sites (29 and 47) fall into the next group of 10 while one site falls into ranks 21 - 30 and three sites fall into ranks 31 - 40 for both methods. The 83 Screen does agree with the 83 SAS as to which sites have the lowest ranks with seven sites (38, 17, 36, 19, 35, and 40) falling into the 41 - 50 group. When the rank of the top 20 sites are compared, 10 of the 20 sites were identified as being among the top 20 sites by both systems while 12 sites were identified as being in the bottom 20 sites by both systems. This shows that while there is little correlation between the two systems, the 83 screen does appear to discriminate between the most severe and least severe sites as measured by the 83 SAS score.

However, the 83 Screen does not predict an individual site's rank nor detect which sites are the most severe. Table 5.4 shows the regression coefficients and statistics of the relationship between the two systems. With a parametric Pearson correlation coefficient of 0.48 and a nonparametric Kendall correlation coefficient of 0.27, it is clear that the relationship between the two systems is not reliable. The reason for this lack of correlation appears to reflect one of the flaws of the screening system which places 9 of the possible 15 points in two basic

Table 5.4 Pearson and Kendall Rank Correlation Coefficients Between the 1983 Screen and the 1983 Site Assessment System and Between the Revised Screen and the Revised Site Assessment System

	Pearson Coefficient		Kendall Rank Coefficient	
	83 Screen vs 83 SAS	R Screen vs RSAS	83 Screen vs 83 SAS	Rscreen vs RSAS
	0.48	0.67	0.27	0.48
N	50	50	50	50
P	0.00	0.00	0.04	0.00

categories: existing exposure and chemical hazard. This illustrates that the structure and point distribution of the 83 Screen and 83 SAS are quite different. The 83 Screen was developed independently and the concepts employed in the 83 SAS were not incorporated into the screening system. Thus, the 83 Screen appears to be applicable as a threshold for determining which sites should be evaluated further but is not reliable for deciding which site should receive priority.

5.5 Relationship Between R Screen And RSAS

The R Screen has a better chance to predict the relative severity of sites (as ranked by the RSAS) than the 83 screen (as ranked by the 83 SAS). This is illustrated by the fact that the two highest ranking sites (Site 7 and 8) in both R Screen and RSAS are the same and four sites (Sites 7, 8, 49, and 29) are ranked among the top 10 sites by both systems. Three sites fall into the rank 11-20 group and two sites fall into the 21-30, group although only four sites fall into the 41-50 group. Fourteen sites fall into the top 20 group while 13 fall into the bottom 20 group. This indicates that there is a better relationship between the R Screen and RSAS systems than there is between the 83 Screen and 83 SAS, with a better ability of the R Screen system than the 83 Screen to identify the most significant and least significant sites.

This conclusion is borne out by Pearson correlation coefficients examining the relationship between the 83 Screen and the 83 SAS and between the R Screen and RSAS (Table 5.4). While neither coefficient is high (83 Screen to 83 SAS is 0.48 and R Screen to RSAS is 0.68) there is substantial improvement in the relationship between R Screen and RSAS. When the ranks generated by the scoring systems are compared using non-parametric Kendall correlation coefficients (Table 5.4), the relationship is weaker. The rank relationship for the 83 Screen to the 83 SAS is only 0.27 while the rank relationship between the R Screen and RSAS is 0.48. The relationship is undoubtedly masked by the number of "ties" in the screening systems where several sites tie for the same rank. The screening systems do not discriminate among the sites as well as the detailed scores. This also means that the site rank cannot be predicted by the site score. This is to be expected, however, because rank is dependant on the number of sites as well as their scores. If there are a large number of sites, rankings will be distorted by ties.

5.6 Test Site Group Performance

The 50 test sites evaluated in this study were divided into ten groups of contamination incidents: landfills, underground storage tanks, heavy manufacturing, chemical manufacturing, salt releases, single chemical or solvent releases, single medium releases, surface releases, lagoon incidents, high ranking sites, and low ranking sites. The performance of the 83 SAS and its ability to determine the relative risk is evaluated in the subchapters below. These groups are examined for score and rank clumping or splitting, important scoring parameters which explain score clumping or splitting, and parameters which relate to site hazard but may be inadequately considered in the models.

5.6.1 Landfill Test Group

Landfills were the single largest group evaluated, in part because they represent the most diverse group of sites and they are the most commonly perceived type of contamination site. As shown in Table 5.5, fifteen sites fit into this classification although some subdivision of this category is appropriate. Landfill subcategories include sanitary, industrial, barrel dumps, and specialty fills with overlap in some cases. In general, the performance of both models in assessing the landfill test group was quite good. This may be due, in part, to awareness of this type of facility by the 83 SAS committee during model development.

No significant ranking changes occurred for the sanitary landfill group where most of the rankings were nearly identical between the two models. In two cases, Sanitary Landfill No. 1 and Oliver's Sanitary Landfill, RSAS rankings were higher. The relative increase in score is attributable to increased migration potential factors over the 83 SAS release potential factor caused by the environmental fate factors. At both sites, the nature of the soils and waste indicated that enhanced migration could occur. In addition, documented environmental contamination raised the existing exposure score at both sites.

The least amount of agreement between rankings by the two models was found for landfills involving industrial wastes. With the exception of G and H Landfill, RSAS rankings were lower than 83 SAS rankings. At three of the six landfills; Bay City Middlegrounds, Poseyville Landfill,

Table 5.5 Landfill Site Test Group

Site		1	2	3	4	83 SAS		RSAS	
No	Site Name	San.	Ind.	Bar.	Spec.	Rank	Score	Rank	Score
1	Sanitary Landfill No. 1	X				39	440	32	691
4	Oliver's Sanitary Landfill	X				44	289	39	561
35	Crystal Falls Dump	X				45	280	46	417
36	Bates Township Dump	X				43	300	44	427
38	Tri City Landfill	X				48	233	47	411
24	Selfridge ANG	X	X			5	891	12	1661
31	Dial Trucking	X	X			32	530	38	569
48	Bay City Middlegrounds	X	X			13	838	36	582
33	Poseyville Landfill		X			26	683	42	516
8	G and H Landfill		X		X	4	949	2	1991
45	Cannalton Landfill		X		X	2	983	22	1042
14	Dulaur Products Inc.			X		31	563	45	421
15	Harsen's Island			X		33	517	37	570
39	Darling Road Dump			X		24	701	21	1287
21	Detroit Edison Dredged Spoils				X	17	796	14	1639

1 San. = Sanitary
2 Ind. = Industrial
3 Bar. = Barrel Dump
4 Spec. = Specialty

and Cannalton Landfill; the drop in rank was significant. A relative reduction in chemical hazard score was responsible, driven by the change in the waste quantity scale to 1 to 10,000 kg. The lower ceiling in the 83 SAS resulted in maximum scores. The Bay City Middlegrounds score was also affected by a reduction in the migration potential factor in RSAS because several of the contaminants are expected to bind in soils.

Reduction in migration potential also accounted for the lower rankings attained by Selfridge Air National Guard Base, Dial Trucking, and DuLaur Products when assessed by the RSAS. The presence of continuous, thick clay layers resulted in a reduction of the migration potential by the environmental fate factor.

Finally, in RSAS ranking, human population size was less of a driving force, not because the relative scores were lower but because the environmental resource scores were higher. This was apparent at several sites where surface water or ground water contamination has occurred but human populations weren't affected. In 1983 SAS, these didn't score under existing exposure but did in the revised SAS.

5.6.2 Underground Storage Tank Or Fuel Incident Test Group

The underground storage tank or fuel incident sites evaluated are identified in Table 5.6. All of the UST sites were evaluated using the O'Dell's Gas City method which was developed by Department staff and appended to the 83 SAS. The method was developed because the 83 SAS did not provide a method for scoring gasoline incidents. In particular,

Table 5.6 Underground Storage Tanks or Fuel Incidents

Site No.	Site Name	UST	Other	83 SAS Rank	83 SAS Score	RSAS Rank	RSAS Score
25	Herman Radio Tower	X		30	573	25	984
26	Trading Post	X		20	740	3	1926
27	US 41 Birch Creek	X		40	398	9	1748
28	O'Dell's Gas City	X		35	510	11	1675
9	Abandoned Tank Farm, Lower Harbor		X	23	730	6	1771
22	E Columbia Rd GW Contamination		X	22	734	26	919
23	Res Wells Village of Meredith		X	8	878	23	1026
24	Selfridge ANG Base		X	5	891	12	1661

waste quantity could not be estimated according to rules in the model. The O'Dell's method set criteria which allowed the scorer to select between a 200 or 2,000 gallon discharge and obtain a preset chemical hazard score.

In concept, this was a reasonable solution to the problem. However, the selection of waste quantities proved to be underestimated when contaminated soils or recoverable product were removed. The chemical hazard points available (150 for a 200 gallon spill and 250 for a 2,000 gallon spill) were low relative to the quantity of waste and the maximum number of points available in the compartment (450). Many of the sites, typified by three of the first four sites in Table 5.6, received low or moderate site scores in the 83 SAS even though releases had occurred and, in the case of O'Dell's Gas City and U.S. 41 Birch Creek, migrated from the immediate release area and had contaminated drinking water wells. In both of these cases, while drinking water wells were contaminated, the existing exposure points were low because the number of wells affected and concentrations detected were low. The Trading Post site received a higher score because several tanks were involved and the higher chemical hazard score was obtained. The site is also near surface water and the surface water score was higher than the other sites.

With the RSAS, US 41 and O'Dell's became more prominent than the Herman Radio Tower because the quantities released were larger and ground water contamination occurred. Direct calculation of the waste quantity allowed better discrimination among the sites rather than the chemical hazard default selection in the 83 SAS. This default selection in the 83 SAS tended to cause sites to clump. The degree of environmental contamination and human impact also resulted in greater discrimination. The Herman site is geographically remote in contrast to the other sites and yet, because there was less evaluation of extent of contamination in the 83 SAS, it had scored higher than US41 and O'Dell's. The overall shift to higher scores for the gasoline incidents also reflects the greater importance relative to other contamination site incidents where waste release is less likely and the waste does not persist as a liquid. The relative rise in site rank from 20, 30, 35, and 40 in the 83 SAS to 3, 26, 11, and 9, respectively, reflects the greater importance of this type of incident.

The other fuel incidents involved concentration based scoring methods in the 83 SAS and resulted in relatively high scores due to the area population densities. Chemical hazard scores reached the compartment maximum, but differences in environmental resource compartment scores resulted in good discrimination among sites. The Selfridge ANG Base is an interesting site because there were several containment structures on site which did not contribute significantly to the overall site score. The high score and rank for this site occurred because the chemical hazard score reached the maximum value and a significant potential for surface water contamination was projected. The large quantity of waste on site would have supported a significantly higher chemical hazard score if the point ceiling was higher. The population at risk was low because the containment structures were centered on the large base property and most of the residential areas were outside the one-half mile radius.

In the revised model, the UST sites received higher scores and prominence than they had in the 83 SAS (Table 5.6). The principle reasons for this were the existing exposure points awarded for contaminated environmental resources and an increase in the chemical hazard score. The increase in the chemical hazard score occurred because individual contaminant toxicities were more severe, in part, than in the 83 SAS and the waste quantity estimation methods were improved. The quantity of waste used in the O'Dell's method default scoring (when the actual losses are not known) was increased from 200 or 2,000 gallons to 300 or 3,000 gallons because it was found that these were more typical of quantities lost at UST sites. The methods of estimating waste loss were also improved so that default scoring may could be avoided in many UST cases. For example, methods for estimating the volume of contaminated soil and then deriving waste quantities from concentrations allow quantity calculations which are more accurate than the default values.

In comparison to the 83 SAS, only one of the sites (Selfridge ANG Base) obtained the maximum chemical hazard score with the revised model. It is appropriate that Selfridge reached the maximum because of the very large amount of waste in the various containment structures on site. The Abandoned Tank Farm site score rose significantly due to observed contamination of both ground water and surface water. Existing exposure received no points in the 83 SAS because human populations were not impacted. Overall, the relative ranks of these sites in the test universe slipped in importance from 5, 8, 22, and 23 in the 83 SAS to 12, 24, 27, and 26 respectively in the revised model. This slippage was due to the rise in importance of other sites as much as the decline in importance of these sites. The discrimination that resulted from the expanded chemical hazard point scale and the removal of the direct contact compartment accounted for much of the change.

5.6.3 Heavy Manufacturing Facilities Test Group

The five heavy manufacturing facilities evaluated in this study are shown in Table 5.7. The distribution of site scores from both models did not reveal any clumping and appeared related to the number of environmental media which were contaminated. The relationship between the number of environmental media impacted or released to and the site rank was stronger in the revised model evaluation than in the 83 SAS. The relative importance of the five heavy manufacturing sites (shown in Table 5.8) generally went up in rank with Former Rancour climbing from rank 9 in the 83 SAS to 4 in the revised model.

Two sites, Former Rancour and Peerless Plating, where soils, ground water, and surface water were impacted, scored and ranked highest. They both rose in prominence relative to their rank in the 83 SAS model. Peerless Plating also involved soil, ground water, and surface water contamination but scored about 200 points less. This was in spite of high concentrations being found in the surface water which resulted from ground water contamination. Auto Specialties, which had ranked 11 in

Table 5.7 Heavy Manufacturing Facilities Test Group

Site		83 SAS		RSAS	
No.	Site Name	Rank	Score	Rank	Score
2	Peerless Plating	25	687	36	596
6	Auto Specialties	11	847	18	1404
10	Douglas Components	36	504	28	809
18	Severance Tool	38	441	40	542
37	Former Rancour	9	868	4	1910

the 83 SAS slipped to 19 in the revised model, still with a significant score.

Douglas Components, which had not received any points for ground water contamination in the 83 SAS because there is no population at risk, received points for contaminated ground water in the RSAS and rose in importance due to this environmental release. This is appropriate since a known release is of greater consequence both for existing impact as well as potential impact than a site where only a potential for release exists. The relative importance of the remaining heavy manufacturing site, Severance Tool, remained essentially the same in the revised model as it had in the 83 SAS. A release to soils with no environmental or human population impact dropped the site to rank 40 from 38 in the 83 SAS. While the site scores for the other heavy manufacturing sites rose at least 300 points and as much as 1,100 points, Severance Tool rose only 101 points indicating that the site holds little concern for significant migration or impact even though it qualifies as a contamination site.

5.6.4 Chemical Manufacturing Facilities Test Group

Only three facilities involving chemical manufacturing or specialized treatment facilities were evaluated (Table 5.8). Ott-Story Chemical and Gelman Sciences were selected because of their prominence in the Act 307 Priority Lists. These chemical manufacturing facilities were assessed by the revised model as being significant and high ranking in the test

Table 5.8 Chemical Products Facilities Test Group

Site		83 SAS		RSAS	
No.	Site Name	Rank	Score	Rank	Score
7	Story Chemical Co.	1	1058	1	2028
11	Old Koppers Hersey River	21	734	5	1836
49	Gelman Sciences Inc.	6	886	10	1741

group. All three sites were ranked in the top 10 sites by both models, with Ott-Story retaining its number one rank.

Ott-Story scored high in the 83 SAS because of the extensive ground water contamination (a one mile plume discharging to a creek tributary to the Muskegon River), free-floating solvents on the water table at the release point, and contamination of surface water. In RSAS scoring, the site score rose due to the detection of contaminants in both ground water and surface water which resulted in environmental resource existing exposure scores for both compartments. The site deserved to retain its high score and rank due to the quantity of remaining waste and continuing migration of contamination. Even though the waste source has been removed so that further releases will not occur, the amount of contaminants already released and their zone of influence resulted in the maximum 83 SAS chemical hazard score.

The Gelman Sciences score of 886 resulted in a rank of sixth in the 83 SAS and 10th in RSAS. While the concentrations of contaminant are low over much of the plume area, the large size of the plumes (nearly three miles to the northwest and one-one half miles to the northeast in a deeper aquifer) has resulted in a large zone of influence. Overland flow has also resulted in contamination of a nearby small lake and some unremediated contamination of private wells remains. The chemical hazard score did not reach the maximum score possible in the 83 SAS due to the calculated quantities of contaminant released. The Gelman Sciences site slipped in rank not because its score didn't rise in the revised model but because a few other sites rose in score and rank.

Like the Ott-Storey site, Gelman increased in score largely due to the increase in model score scales although the population at risk scores rose due to zone of influence changes and the greater emphasis on recreational exposure in the surface water compartment. Existing exposure points were awarded due to contamination of ground and surface waters over and above their use as drinking water supplies.

The Old Koppers site scored and ranked lower in the 83 SAS (rank 21 and 734 score) than might be expected. Like Ott-Storey, contaminants (creosote, heavy with PNAs) are free-floating on the water table and have been released to the nearby Hersey River. The site scores relatively low in the 83 SAS due to the low release potential factor for the ground water compartment due to the characterization of the soil contamination as stained and the waste being considered a sludge at the time of release. The lack of drinking water wells at risk eliminated population at risk scores although recreational exposure potential and a low surface water existing exposure assessment due to a fish advisory was made. Because of the known water table contamination and migration to surface water, the site presents a greater hazard than assessed by the 83 SAS.

The Old Koppers site rose in rank from 21st in 83 SAS to fifth in the revised model. This rise in rank and score more appropriately reflects the risk at the site from existing contamination and the potential for further contamination. The migration potential values in both ground water and surface water rose due to the environmental fate factors recognizing that the soil medium has a low potential for impeding migration. The contamination of ground water and migration to surface water also contributed to the rise in the surface water compartment migration potential score. Another reason for the site score increase was the points awarded in existing exposure for contamination of ground and surface waters. Absent drinking water population at risk and contaminated drinking water supplies, the detection of contaminants in monitoring wells and Hersey River sediments assigned points to the inherent value of these resources. The potential for recreational exposure to surface water also resulted in higher population at risk scores in the surface water compartment.

5.6.5 Salt, Brine, Or Nitrate Incident Test Group

Brine and nitrate contamination incidents (Table 5.9) are evaluated as relatively insignificant by both models. This is due to the low potential toxicity evaluation of the contaminants which is based upon their low hazard to humans. The low chemical hazard scores for all of these sites, even when the zone of influence is large (as in the Penninsula Twp. site) ensures a low score. This evaluation is appropriate since impacts are essentially aesthetic and treatable at the point of water use (drinking water). Localized land surface impacts are more severe, however, due to the impact on vegetation.

All of the sites evaluated, except the Pool Co. Area site, dropped a few positions in rank. In each case the chemical hazard scores remained low and migration potential was reduced due to the environmental fate assessment. These reductions were offset by points awarded for existing

Table 5.9 Salt, Brine, or Nitrate Incident Test Group

Site		83 SAS		RSAS	
No.	Site Name	Rank	Score	Rank	Score
12	Pool Co. Area	47	243	27	908
18	Boardman lake	41	389	43	501
40	Osceola Co. Road Commission	49	195	48	358
41	Penninsula Township	28	606	29	766
42	Ricci Oil Well	29	580	34	605

exposure where drinking water wells were affected or ground or surface waters were contaminated. The Pool Co. area site rank rose due to an increase in the chemical hazard score and the contamination of ground water. The chemical hazard score rose at the Pool Co. site due to the large amount of brine involved and the change in point distribution of hydrocarbon potential toxicity. Overall, the scores and ranks of these sites were appropriate to the relative risk associated with this type of contamination incident.

5.6.6 Single Chemical Or Solvent Release Facility Test Group

With the exception of Thomas Solvents Rawsonville, the single chemical or solvent release incidents (Table 5.10) were generally of lesser significance than other sites. This perspective is appropriate for these sites because there were no observed releases to ground or surface waters at three of the sites, although soil releases were observed.

The rankings of the other sites slipped a few positions. Washout Laundry received existing exposure points in the revised model for contaminated ground water but none of the other sites involved environmental releases. A major factor in each of the reduced site scores was the reduction in migration potential scores due to the adsorptive capacity of the receiving soils and expected impedence of contaminant migration. This drop was due to the environmental fate factor in the migration potential parameter. the reduced migration potential parameter reflects conditions at the sites because, while there have been releases to soils, no contamination of ground water or

Table 5.10 Single Chemical or Solvent Release Incident Test Group

Site No.	Site Name	83 SAS Rank	83 SAS Score	RSAS Rank	RSAS Score
5	Washout Laundry	34	510	41	521
17	Belfer Drum	46	260	49	296
19	Mount Elliott Drum Site	42	330	50	268
29	Thomas Solvents Rawsonville	14	837	7	1771
32	Liquid Disposal Inc.	27	667	30	750

surface water resources has been observed. Belfer Drum and Mount Elliott Drum slipped to the lowest ranking sites essentially due to the low potential for further migration and low quantities of waste on site. In both cases, drums have been removed and paving over the remaining contaminated soils at Belfer results in little remaining risk at these sites.

Of the sites in this test group, only the risk at Thomas Solvents appeared to have been underestimated by the 83 SAS. At this site, releases to ground and surface waters were not scored by the 83 SAS because only the resources had been impacted, not drinking water supplies. The releases to ground and surface water were scored in existing exposure by RSAS documenting the additional risk associated with migrating contaminants. The release potential factor in the 83 SAS was also low because of the small quantity of waste available to migration in the air compartment. This quantity was greater in the revised model and the migration potential was further enhanced by the high volatility of the contaminants as evaluated by the environmental fate factor. Finally, in the 83 SAS waste quantity estimation, the chemical hazard value was derived by waste characterization rather than the calculation of individual contaminant quantities and levels of concern as required by the hierarchy in the revised model. Once the above factors were corrected during scoring with the revised model, a more appropriate rank of seventh overall was obtained.

5.6.7 Test Group Sites Involving Only Single Medium Contamination

Six test group sites were scored exclusively in one medium according to a special condition mechanism in the 83 SAS. Three of these sites were scored for the ground water compartment and three were scored for the surface water compartment (Table 5.11). Scoring by this mechanism is required in the 83 SAS when contamination has been discovered in an environmental medium but no source of the contamination has been identified. When only two of the six compartments are scored under this condition in the 83 SAS, the site is limited in its maximum score.

Three of these sites (Saginaw River, Saginaw Bay; Res. Wells Village of Meredith; and Torch Lake) ranked in the top 10 acording to the 83 SAS, all having attained the chemical hazard maximum of 450 points. Two sites (East Columbia Road Contamination and Ferrysburg Area) ranked near the middle in significance due in large part to moderately high chemical hazard scores of 360 and 320 respectively. The lowest ranking site in this group (Boardman Lake) only scored 50 points in chemical hazard. As discusssed in section 5.5, this site involved a brine release which has a low potential toxicity score.

The bias of the 83 SAS toward human risk at the expense of environmental risk also had a major impact on this group's site scores. All of the higher scoring sites were in areas of large population or in the middle of population centers. Thus, the three ground water sites were centered in areas where private wells are the source of drinking water or where municipal water supply wells were within the one-half mile radius.

Table 5.11 Test Group Sites Inolving Only Single Medium Contamination

Site				83 SAS		RSAS	
No.	Site Name	GW	SW	Rank	Score	Rank	Score
20	Ferrysburg Area	X		19	722	24	984
22	E. Columbia Rd. Contamination	X		22	734	26	919
23	Res. Wells Village of Meredith	X		8	878	23	1026
13	Boardman Lake Canning Co.		X	41	389	43	501
43	Saginaw River, Saginaw Bay		X	7	885	17	1542
50	Torch Lake		X	10	850	16	1583

Of the sites evaluated, only the Saginaw River, Saginaw Bay site represents a substantial risk, in large part due to the large area affected. The other major reason for considering this a significant site is the nature of the contaminant (PCBs); its toxicity and persistence. Torch Lake illustrates how a surface water site score can easily approach its maximum. Aside from drinking water population, the 1983 SAS parameters are based on the proximity of the contaminant to surface water and all sites reach the maximum since the water body itself is the site.

All test group sites lost rank when scored with the revised model. The three sites which had been ranked in the top 10 by the 83 SAS fell to 10 to 20 or below. Some of this decline is due to the rise in importance of other sites such as numbers 9, 11, 26, 28, 16, and 27 which climbed into the top 20 sites from outside that group in the 83 SAS rankings. However, the relative slip in importance is generally appropriate due to the single medium nature of the contamination incident and, in the ground water compartment, mitigation by removing the human population from exposure via contaminated drinking water. As discussed earlier, the Boardman Lake site is insignificant due to its low brine contamination risk and ranks low. All of the other sites had increased scores due to the existing exposure points for contaminated resources other than simply human impact. The most important reason for rise in site scores, however, is the expanded chemical hazard point scales where large quantities of waste are present. This explains the Torch Lake and Saginaw River, Saginaw Bay scores where very large quantities allowed these sites to reach the maximum chemical hazard score.

As discussed in above, the Saginaw River, Saginaw Bay site is physically large and is located in a major population center. The site ranked relatively high in the 83 SAS score and should be considered a significant site. Its loss in prominence is due, in part, to the increase in score of the other sites ranked above it. However, the other reason for the failure to obtain a high score is the decision to alter the migration potential value by the environmental fate factor. Where all sites in this group had obtained a maximum release potential score because the medium had been contaminated, the environmental fate factor reduces the migration potential score. This is appropriate, however, because the continued migration of the contaminants is a factor in the overall continuing site risk. In the case of Saginaw River and Bay, the PCBs are bound in lacustrine sediments and, to some extent, covered by uncontaminated or less contaminated sediments. The ability to exert adverse impact is thus reduced and other, more active release sites may be more significant.

Although the site rank for Village of Meredith dropped to 23rd when scored by the revised SAS, the site illustrates how the liability of single medium scoring can be reduced. At Meredith, there is a potential for migration of contaminated ground water to surface water and points were assigned in the surface water compartment. This increased the potential contamination portion of the site score which could allow a significant site to score and rank higher and not have a low ceiling placed on its score as is the case in the 83 SAS.

5.6.8 Surface Release Site Test Group

Sites which involved releases or spills to the land surface are listed in Table 5.12. Two of the sites (Old Koppers, Table 5.8, and Thomas Solvents Rawsonville, Table 5.10) have been discussed in other site groupings. They and the other sites in this group are evaluated because of the nature of the contamination situation which could be severe. Significance of risk should be related to the hazard of the contaminants and their migration potential. Surface releases should present the greatest risk because the contaminants are not contained and they are free to migrate. The limiting risk factors are the ability of the soils to bind the contaminants, their hazard, and the chance that the contaminants will come into contact with humans or sensitive environmental resources.

The first three sites involve large quantities of toxic materials as well as documented migration and yet do not rank high in the 83 SAS rankings. Part of the reason for this is that populations at risk are not large. However, the biggest reason is that the contaminated ground and surface water resources are not scored because drinking water supplies are not involved. In addition, the chemical hazard compartment, although at a maximum in the 83 SAS, does not make up a significant proportion of the total possible score. These sites should have ranked higher because the documented resource contamination is evidence of significant contaminant migration and the probability of extensive further migration.

Table 5.12 Surface Release Sites Test Group

Site No.	Site Name	83 SAS Rank	83 SAS Score	RSAS Rank	RSAS Score
3	Carter Industrial	16	820	19	1333
11	Old Koppers	21	734	5	1836
29	Thomas Solvents Rawsonville	14	837	7	1771
30	Thompson Spill	15	826	8	1754
44	Thumb Radiator	12	845	15	1618
47	Whites Bridge Area Contamination	18	789	33	671

The Carter Industrial site ranked relatively high in both models because of the high toxicological hazard of PCBs and the potential for direct contact of a large surrounding population. A removal of high soil concentrations in the surrounding neighborhood and the barrels on plant property reduced the direct contact hazard and yet the site score remained high due to the total PCB quantity remaining. Contaminated soils were covered while plans are being made for final removal, a delay which is acceptable because PCBs, with a high log Kow, are generally bound in soil organic fractions and can be immobile. The site does not pose as high a risk as it had before the direct contact hazard was addressed.

Carter slipped slightly in rank when scored by the RSAS because the contaminants are PCBs which had been released to soils during intentional draining of transformers. While high levels (up to 2,430 mg/kg) were discovered on site, and vehicle trackout and dust dispersal to the surrounding neighborhood resulted in high levels (up to 96,000 mg/kg) away from the release area, the contaminant was concentrated in the top 10 inches of soil. With a high log Kow (6.04) this class of contaminants binds readily into soils and has a low migration potential. The environmental fate factor reduced the migration potential factor for the site and, while the total site score increased with the revised model, its increase was less relative to other sites and the overall rank fell from 16 in the 83 SAS to 20 in the revised model.

Thumb Radiator ranked the highest in 83 SAS (twelfth) without impact to environmental resources because the population at risk was higher and the chemical hazard score again reached the maximum. With no ground water or surface water contaminated, although the potential for surface water contamination is high, this site should not have ranked above the three sites listed above it in Table 5.12.

The scores and rankings of most sites in this group rose substantially when evaluated by the revised model. It is appropriate that this occured because they represent the greatest potential for contamination site risk. Released hazardous compounds which have migrated and which have the potential for further migration present the greatest risk to the environment. Old Koppers, Thomas Solvents, and Thompson Spill rose to fifth, seventh, and eighth in the revised rankings from 21st, 14th, and 15th in the 83 SAS. These ranks more truly represent the hazard associated with these sites because ground and surface water resources have been impacted at Koppers and Thomas while ground water has been impacted at Thompson.

The Whites Bridge Area Contamination site ranked high due in large part to the maximum chemical hazard score and direct contact hazard. While ground water contamination exists, no points are awarded because human drinking water supplies have not been impacted. As at Carter, the RSAS migration potential is reduced this time because the contaminants are heavy metals. These contaminants bind into soils and the continuing migration to ground or surface waters is reduced. Another factor in the score reduction is the assessment of chemical hazard. In the 83 SAS, the waste quantity reached the maximum score while in the revised model, the contaminants scores did not total as high due to revision of the quantity ranges.

5.6.9 Lagoon Incident Site Test Group

Three of the test sites (Table 5.13) involved lagoon contamination incidents. None of the lagoon systems are currently operating although the Packaging Corp. of America (PCA) lagoon was converted to a landfill after being pumped dry. The PCA and Menasha lagoons were built as seepage lagoons for paper mills and received liquid sludges and black liquor. Most of the sludges were removed at Menasha before capping, but they were not removed at PCA and continued use as a landfill has resulted in water infiltration and extensive ground water contamination at this site.

PCA rose from 37th to 13th in the revised model and this significant rise reflects the hazard remaining at the site even though the lagoon system has been removed. The lagoons received liquid waste but were only pumped out before conversion into a landfill. Water infiltration continues and the soluble liquid waste has migrated through the bottom of the former seepage lagoons. Ground water is contaminated but no drinking water wells have been impacted. Points were awarded in the revised model for resource contamination to reflect this condition. An important change in the revised score, however, is the rise in the migration potential factor. The remaining wastes are quite soluble and the environmental fate factor increased the migration potential score in

Table 5.13 Lagoon Incident Sites Test Group

Site No.	Site Name	83 SAS Rank	83 SAS Score	RSAS Rank	RSAS Score
16	Packaging Corporation of America	37	482	13	1643
32	Liquid Disposal Inc.	27	667	30	750
34	Menasha Corporation	50	150	31	713

comparison to the 83 SAS. The chemical hazard score also rose due to the change in the waste quantity scales.

At Menasha, the site score also rose resulting in a rank change from 50th to 31st. The increase again was attributable to an increase in the migration potential score due to modification by the environmental fate factor. No observed contamination resulted in no points for existing exposure and the relatively small waste quantity resulted in only a small increase in the chemical hazard score. Menasha also has a moderate potential for contamination of surface water by ground water, a factor not considered in the 83 SAS. The site is appropriately ranked near the middle of the group of 50, not as the least important site as it had been ranked by the 83 SAS.

The Liquid Disposal Inc. rank dropped a few levels from 27th in the 83 SAS to 30th in the revised model. This does not represent a significant change in rank and the site is properly viewed as a moderate site risk. Waste has been removed from the site but the migration potential is still high. In the 83 SAS the chemical hazard score reached the maximum value because of the waste characterization method and the ceiling of the waste quantity scales. In the revised model the expanded waste quantity scales resulted in a lower score. The relative loss of chemical hazard score was offset by the increase in migration potential by the environmental fate factor. The result was an increase in the compartment scores even though there is no documented ground or surface water contamination.

5.6.10 High Ranking Sites Test Groups

Table 5.14 lists the top ten ranking sites as scored by the 83 SAS and Table 5.15 lists the highest ranking RSAS sites. All of these sites have been discussed in above subsections and a detailed review will not be repeated. Some comments will be made concerning whether the sites should be among the most significant sites in the test group.

Story Chemical is ranked as the most significant site by both the 83 SAS and RSAS and is a serious site. On-going migration of moderately soluble wastes in the ground water and contamination of surface water with large quantities of waste qualify this as a significant site. Similarly, G and H Landfill, Gelman Sciences, and Former Rancour ranked in the top 10 sites as assessed by both models. All of these sites have high migration potential, human and environmental resource impact, large waste quantity, and high waste toxicity in common and are important sites. They also have continuing migration of contaminants as identified by the existing exposure scores for resource impact and environmental fate factors.

Selfridge ANG Base, also represents significant opportunities for continuing migration of contaminants with significant risk to human populations and environmental resources. It has a large amount of diversified waste in the various containment structures on site. It did not rank in the top 10 as assessed by RSAS, however, due largely to increases in site scores by other sites which supplanted it. It ranked 12th and this does not represent a significant drop in rank.

Table 5.14 1983 Site Assessment System High Ranking Sites Test Group

Site No.	Site Name	83 SAS Rank	83 SAS Score
7	Story Chemical	1	1058
45	Cannalton	2	983
46	Allied Paper/Portage Creek/Kalamazoo	3	969
8	G & H Landfill	4	949
24	Selfridge ANG Base	5	891
49	Gelman Sciences	6	886
43	Saginaw River, Saginaw Bay	7	885
23	Res Wells Village of Meredith	8	878
37	Former Rancour	9	868
50	Torch Lake	10	850

Table 5.15 Revised Model High Ranking Site Test Group

Site No.	Site Name	RSAS Rank	RSAS Score
7	Story Chemical	1	2028
8	G & H Landfill	2	1991
26	Trading Post	3	1926
37	Former Rancour	4	1910
11	Old Koppers Hersey River	5	1836
9	Abandoned Tank Farm Lower Harbor	6	1771
29	Thomas Solvents Rawsonville	7	1771
30	Thompson Spill	8	1754
27	US 41 Birch Creek Res Wells	9	1748
49	Gelman Sciences	10	1741

Ranked second by 83 SAS and 23rd by RSAS, Cannalton presents a problem. While the human exposure potential is low and the migration potential is moderate, the large quantity and high toxicological hazard of the waste calls for consideration as an important site. While the site is probably not the second most important site in the test group, it should have remained among the ten most important sites in the revised model rankings. This site slipped to 23rd overall largely because the environmental fate factor assessed the migration potential as relatively low. Ordinarily this would be true because the contaminants are heavy metals, mostly chromium, which binds to soils. At the site, however, the waste is uncovered and subject to flooding with large amounts of material periodically being washed into the St. Mary's River. There is continuing contamination of surface water although the risk to ground water is low because of the nearby river. Overall, the site should have been ranked among the ten most important sites but this would have required recognition of unusual conditions.

In contrast, reduced opportunities for extensive further migration and resource contamination suggest that Allied Paper/Portage Creek/Kalamazoo River, Saginaw River, Saginaw Bay, Res Wells Village of Meredith, and Torch Lake should not rank among the most important sites. Kalamazoo River, Saginaw River, and Torch Lake are typified by PCB or heavy metal contamination which have migrated to sink areas from which little further migration is likely and human exposure, except through fish ingestion, is unlikely. At Meredith, the drinking water impact and large chemical hazard score generated by the concentration scales over emphasized the site.

Six sites, Trading Post, Old Koppers/Hersey River, Abandoned Tank Farm Lower Harbor, Thomas Solvents Rawsonville, Thompson Spill, and US 41 Birch Creek Residential Wells, were identified as among the ten most important sites by the revised model. These sites replaced Cannalton, Allied Paper/Portage Creek/ Kalamazoo River, Saginaw River/Saginaw Bay, Res Well Village of Meredith, and Torch Lake from the 83 SAS list (Table 5.15). Like the four sites which were also ranked in the top ten by both models, the new sites have high waste quantity scores, contamination of environmental resources, and high further migration potential.

The US 41 site, however, appears to be over-emphasized. With an unknown source for the fuel release, this site was scored by the waste approximation approach of the O'Dell's method as required by the waste quantification hierarchy in chemical hazard scoring. This defaulted to a high chemical hazard score. While continuing migration will endanger more potable water supply wells and surface waters are nearby, the population is relatively low and the waste quantity is moderate. The site is important, but probably should not be ranked among the ten most important sites.

5.6.11 Low Ranking Sites Test Groups

Table 5.16 lists the test group sites which scored and ranked in the lowest ten using the 83 SAS while Table 5.17 lists the lowest ranking RSAS sites. As noted for the high ranking sites, these sites have been discussed in the various contamination incident groups and will not be

Table 5.16 1983 Site Assessment System Low Ranking Sites Test Group

Site		83 SAS	
No.	Sit Name	Rank	Score
34	Menasha Corp	50	150
40	Osceola Co. Rd. Comm.	49	195
38	Tri City Refuse	48	233
12	Pool Co. Area	47	243
17	Belfer Drum	46	260
35	Crystal Falls Twp. Dump	45	280
4	Oliver's Sanitary Lf.	44	289
36	Bates Township Dump	43	300
19	Mt. Elliott Drum Site	42	330
13	Boardman Lake	41	389

Table 5.17 Revised Model Low Ranking Site Test Group

Site No.	Site Name	RSAS Rank	RSAS Score
19	Mt. Elliott Drum Site	50	268
17	Belfer Drum	49	296
40	Osceola Co. Rd. Comm.	48	358
38	Tri City Refuse	47	411
35	Crystall Falls Twp Dump	46	417
14	DuLaur Products	45	421
36	Bates Township Dump	44	427
13	Boardman Lake	43	501
33	Poseyville Landfill	42	516
5	Washout Laundry	41	521

reviewed here. Both models identify seven of the sites as relatively insignificant and belonging in the lowest risk group. Six of the sites involve salt or brine incidents or remote township landfills with little toxicological risk associated with the wastes. Although mobile, salt or brine incidents involved low waste quantities. The township landfills are remote sanitary waste dumps with no nearby populations to impact. Migration potential is low or moderate and population densities and risk is also low with little potential for contamination of environmental resources. One site, Belfer Drum, involves PCBs but they have been covered by part of a building and parking lot which effectively reduces an already low potential for migration. Relatively low quantities of waste and a low surrounding population also minimizes the site risk.

Two sites identified by the 83 SAS as being in the least significant group, Menasha Corp. and Pool Co. Area, involve hazardous materials in situations which may provide for significant migration. Menasha involved pulp and paper waste disposal to wastewater lagoons although no environmental contamination has been detected. The Pool Co. Area involved brines from an oil field but also included crude oil contamination and a greater toxicity. Both sites, however, were in areas of low or moderate population density and the potential for surface water contamination was also low. Therefore, while not particularly hazardous sites, their toxicity and migration potential were inadequately evaluated by the 83 SAS and they do not belong among the ten least important sites of the test group.

Oliver's Sanitary Landfill was also identified by the 83 SAS as being ranked among the 10 least important sites while the RSAS did not. The difference in their rankings (44th and 39th respectively) is not significant. Assessments of population, toxicity, and quantity are similar among the two models. The difference appears to be due to a higher migration potential assessment in the RSAS because porous soils are found in the vicinity of the landfill. Also contributing to the higher rank is the RSAS assessment of lesser risk for Washout Laundry, Poseyville Landfill, and DuLaur Products. These sites replaced Oliver's, Menasha Corp., and Pool Co. Area on the lowest ranking sites list.

Two sites, Washout Laundry and Poseyville Landfill replaced Menasha Corp and Pool Co. Area as being among the least important sites by the 83 SAS. Washout Laundry involves a small ground water plume with low concentrations of tetrachloroethylene but no contaminated drinking water wells. While ground water risk is relatively high, the lack of any significant surface water risk and low waste quantity kept this site from ranking very high. This site probably should have ranked higher because of the nature of the contaminant and the location of the site (within a moderately populated area) but the above migration and quantity conditions of the revised model kept the site from scoring higher.

At first glance, Poseyville Landfill appears considerably more important than assessed by the revised model. It is a 74 acre industrial landfill with known ground water contamination. However, installation of a purge well system has limited the chance of further migration from the site and the landfill has been recapped with clay to limit further infiltration of water. Coupled with a low human population and no surface water within the one-half mile radius, the site is controlled and presents little risk for further contaminant migration. Finally, relatively low pure chemical waste quantities were calculated for the site and a low chemical hazard score resulted. Therefore it appears that the revised model calculated an appropriate score for the site and it should rank among the less important of the test sites.

DuLaur Products was ranked 31st by the 83 SAS while it ranked 45th according to RSAS. As noted above for Oliver's, the reason relates to migration potential. The ground water migration potential was reduced by the environmental fate factor because of the presence of continuous, thick clay layers in the vicinity of the site.

6.0 Conclusions and Recommendations

Overall, the revised model represents a significant improvement from the 83 SAS. While there is no such thing as a "right" model or rank the revised model does improve on the method of evaluation and identifies the sites which represent the most risk. As a structured value system, the revised model considers sites which involve high migration potential and large quantities of toxic materials as most important. It has reduced the importance of human impact, not by reducing the points awarded to human risk, but by increasing the importance of environmental impact and awarding points to environmental contamination when human impact has not been observed.

6.1 Important Improvements In The Revised Model

There were numerous improvements in the revised model over the 83 SAS. The overall structure of the model was improved and the application and procedures of the model were simplified. There were four major improvements in the model which had significant impact on its application.

Probably the most significant improvement was the development of the environmental fate factor which is used to modify the release potential factor from the 83 SAS. As a result, a more accurate estimation of contaminant migration potential is derived. In the 83 SAS, migration potential was considered strictly related to the physical state of the contaminant. It did not consider the modifications in state nor the potential for adsorption or migration enhancement that contaminants could undergo once they had escaped containment. By basing the environmental fate factor on the physical chemical properties of the contaminant and the ability of the receiving environment to impede migration, a more true evaluation of the migration potential of the contaminants was derived.

Another important improvement was the reduction in importance of human risk by increasing the evaluation of environmental risk. Increases in the zone of influence in the surface water and air compartments and revision of detection methods in the air compartment resulted in more balanced scoring of these compartments. In addition, allocation of points to detected contamination in the existing exposure parameters, when no human impact was observed, resulted in an assessment of risk and value of the environmental resources themselves.

A third important revision was the complete redevelopment and simplification of the chemical hazard compartment. The very involved calculation and scoring method in the 83 SAS was reduced to direct estimation of contaminant and score derivation from quantity/hazard graphs. The assessment of quantity and hazard was made more comparable between the waste characterization and pure compound graphs so a similar score would be obtained by both methods. Once the graphical relationships were developed, a series of equations was developed for direct calculation of the chemical hazard score. This eliminated the uncertainty of interpolation of multiple cycle logarithmic scales on the graphs. Expansion of the chemical hazard score to a level equivalent to the resource compartments placed a more appropriate emphasis on the chemical hazard compartment than in the 83 SAS. It also provided a more appropriate balance between exposure and toxicological hazard in the concept of risk assessment.

Imposition of a waste quantification hierarchy resulted in calculation of the quantity of waste on site only once and a constant application of the extent of contamination throughout the site scoring. Furthermore, a de minimus concept was introduced so that, if a contaminant was found to exert less than a minimal toxicity or exist at less than a minimal quantity, it would not be considered. Thus, if only de minimus quantities are present on site, the site does not qualify as an environmental contamination site.

These revisions resulted in a better identification of significant sites. The 83 SAS had identified several sites with high potential contamination as of greater risk than sites with existing exposure and high potential contamination. The RSAS reversed this trend and emphasized incidents where contaminant release and migration combined with environmental impact and large waste quantities to give high priority to these sites. While there was little difference between the systems in identifying the less important sites, the revised model did a better job of identifying the important sites as defined by the improvements summarized above.

6.2 Further Matters For Review

Two areas of the revised model, the O'Dell's method and removal of direct contact hazard from the detailed model, did not work out as well as anticipated.

The O'Dell's method was modified by increasing the two waste quantity options of 200 or 2,000 gallons of fuel lost to 300 or 3,000 gallons. This change was made to reflect five years of experience with the magnitude of these types of losses. The increase appropriately increased the score separation between the two types of releases but resulted in obtaining the maximum score for the 3,000 gallon incident. This may have over-emphasized the importance or risk of the large quantity release and often led to over-dominance of the site score by the chemical hazard score. While ground water contamination often results from these releases, the area of impact is usually small and environmental impact is often quickly controlled. It appears that the waste quantity scales need further revision. Perhaps more than two options for waste quantity are needed or the quantities could be closer together in size. Another option could be to require use of concentration data when they are available rather than using the default quantities. This special scoring method needs further review.

In the case of direct contact hazard, the decision to remove this parameter from the RSAS score needs to be reevaluated. Removal of the fire and explosion parameter was appropriate and was found to have no impact on site scores. This was largely due to the observation that the parameter was seldom scored and did not impact overall site rank. In addition, when this risk was present, it was usually mitigated within a year which resulted in removal of the points from the site score. This was also the logic applied to the direct contact compartment. However, while often mitigated, the risk often was not completely eliminated because contaminated soils remained on site or access to the site had not been completely restricted. It may be necessary to annually revise the scores for sites where direct contact hazard has been scored instead of eliminating this parameter (which was done partly to reduce the need for annual rescoring). Another option might be to create a soils compartment which would assess the accessable contamination remaining on site, perhaps with a smaller compartment score or an environmental fate factor which considered the potential for site access.

6.3 Recommended Application

The RSAS model is recommended for site scoring and ranking in the Michigan Act 307 Program in place of the 83 SAS. As discussed above, the model has been improved and is more capable of identifying important sites and in distinguishing among them. The revision of the screening system has greatly reduced the chance of obtaining the false negative, the chance that a site may be identified by the screening system to be of less risk than it actually is.

Incorporation of parameters into the screening system which are more comparable to the detailed scoring system has resulted in an improved correlation between the screening system score and the detailed system score. Depending on the needs of the Act 307 program and the personnel resources available to conduct site scoring, a study might be conducted to determine whether the screening system might be sufficient for site ranking. Selection of sites for remedial investigation and feasibility studies may not need the full review of the detailed model because many are being conducted by responsible parties and State funding is available for remedial action at more sites because of passage of the bond program.

ENVIRONMENTAL CONTAMINATION SITE RISK ASSESSMENT AND RANKING IN MICHIGAN: REVISION OF THE SITE ASSESSMENT SYSTEM MODEL

Volume II

By

George Fraser Carpenter

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

1990

Appendix A

1.0 Introduction

The revised Site Assessment System (RSAS) has been developed to replace the 1983 Site Assessment System (SAS), the environmental contamination site risk assessment model mandated by the Michigan Environmental Response Act, Act 307 of the Public Acts of 1982. The SAS was developed in 1983 by an interagency committee to rank Michigan environmental contamination sites for public funding.

The RSAS is the result of recommendations by a public committee convened in 1987 by the Groundwater Quality Division (now the Environmental Response Division) of the Michigan Department of Natural Resources. George Carpenter was the chair of the committee (Table 1.1). The committee made recommendations for changes to the 1983 SAS (SASCOM, 1988) on which this RSAS is based.

The RSAS is a two tiered model. Tier 1, the screening system, is presented in chapter 2. Tier 2, the detailed scoring system, is presented in chapters 3 through 9.

Environmental contamination site scoring should proceed in the order of the sections of this manual. Figure 1.1 shows the structure of the revised screening model and serves as both scoring record and worksheet. Figure 1.2 shows the overall structure of the detailed model and serves as the scoring record. Figure 1.3 is the documentation log sheet which should be filled out in detail as scoring progresses. An explanation of the decisions made during scoring and references for information used, should be recorded here.

Table 1.1 1983 Site Assessment System Model Review Committee

Chair

Mr. George F. Carpenter
Environmental Response Division
Department of Natural Resources

Public Members

Dr. Abdul Abdul
Environmental Science Department
General Motors Research Laboratories

Dr. Frederick L. Brown
Great Lakes United

Mr. William B. French
Wilkins and Wheaton Environmental
Services, Inc.

Dr. W. Randolph Frykberg
City Manager
City of Boyne City

Mr. E.M. Ilgenfritz P.E.
Environmental Services
Dow Chemical Co., U.S.A.

State Agency Representatives

Mr. John Alford
Environmental Response Division
Department of Natural Resources

Dr. James Bedford
Toxic Substances Control
Commission
Department of Natural Resources

Mr. Gary Hurlburt
Surface Water Quality Division
Department of Natural Resources

Mr. Joseph Lovato
Water Supply Division
Department of Public Health

Mr. Edwin Renkie
Office of Toxic Substances and
Emergencies
Department of Agriculture

Dr. Kirpal Sidhu
Center for Environmental Health
Sciences
Department of Public Health

Mr. Robert Teoh
Air Quality Division
Department of Natural Resources

Environmental Contamination

Medium	Potential Contamination	Known Release	Environmental Impact	Human Exposure	
Soils	2	4	6	8	
Ground Water	2	4	6	8	Max 20 pts
Surface Water	2	4	6	8	
Air	2	4	6	8	

Contaminant Mobility

Moderately Mobile	Mobile
3	6

Sensitive Environment Within One-Half Mile 3

Population At Risk

Density per square mile	Points
Less than 100	0
100 - 500	1
500 - 2500	3
More than 2500	5

School, Hospital or Nursing Home Within One-Half Mile 1

Contaminant Concern

Concentration (ppb)	Quantity (kg)	Potential Toxicity Score 5-9	10-14	15-19	20-29	>30
1 - 100	<25	1	3	5	7	9
101 - 1000	25-1250	3	5	7	9	11
1001 - 10000	1251 - 5000	5	7	9	11	13
> 10000	>5000	7	9	11	13	15

or

Acres	Cubic Meters	Waste Type Characterization E	D (5)	C (10)	B (15)	A (20)
<.5	<250	1	3	5	7	9
.5-10	251 0 5000	3	5	7	9	11
11 - 20	5000 - 10000	5	7	9	11	13
>20	>10000	7	9	11	13	15

SITE SCORE (Maximum Possible Points = 50)

Figure 1.1 Revised Site Assesssment System Site Screening Criteria

	AIR		GROUNDWATER		SURFACE WATER	
	RATING FACTOR (Range of Scores)	SITE SCORE	RATING FACTOR (Range of Scores)	SITE SCORE	RATING FACTOR (Range of Scores)	SITE SCORE
	Release Potential (1.0-2.0)		Release Potential (1.0-2.0)		Release Potential (1.0-2.0)	
	Environmental Fate (0.25-2.0)		Environmental Fate (0.4-2.0)		Environmental Fate (0.4-2.0)	
P E O X T P E O N S T U I R A E L	Mobility (0-60)		Overlying Soils (0-100)		Distance to Surface Water (0-20)	
					Site Slope (0-20)	
					Flood Potential (0-10)	
					Fish Ingestion (0-50)	
	Site Activity (0-25)		Useable Aquifer (0-100)		Lake (0-15)	
					Stream (0-10)	
					Wetland (0-15)	
					Cold Water Fishery (0-10)	
	Population At Risk (0-100)		Population At Risk (0-100)		Population At Risk: Drinking (0-100)	
					Population At Risk: Bathing (0-50)	
	POTENTIAL EXPOSURE SCORE (PE)		POTENTIAL EXPOSURE SCORE (PE)		POTENTIAL EXPOSURE SCORE (PE)	
E E X X I P S O T S I U N R G E	On-Site Concentration (0-250)		Wells: Monitoring (0-125)		Environmental Exposure (0-50)	
	Off-Site Concentration (0-150)		Wells: Drinking Water (0-250)		Population: Drinking Water (0-250)	
	Soil Deposition (0-150)		Wells: Irrigation/Livestock (0-50)		Fish Advisory (0-50)	
					Water Supply: Irrigation/Livestock (0-50)	
	EXISTING EXPOSURE SCORE (EE)		EXISTING EXPOSURE SCORE (EE)		EXISTING EXPOSURE SCORE (EE)	
	COMPARTMENT SCORE (PE + EE)		COMPARTMENT SCORE (PE + EE)		COMPARTMENT SCORE (PE + EE)	

Chemical Hazard (0 - 1300)	
Total Site Score ($\sqrt{A^2 + GW^2 + SW^2}$)	

Figure 1.2 Revised Site Assessment System Site Scoresheet

Site Name________________________________ Page______ of ______

Reference Number	Reference

Figure 1.3 RSAS Documentation Log Sheet

2.0 Tier 1, The Screening System

The Screening System is the first tier of the two-tiered Site Assessment System model. It is applied to all environmental contamination incidents which have been declared contamination sites. The Screening System tier is applied to determine whether a site appears to be of sufficient severity to warrant scoring with the second, more detailed, tier of the model in order to rank the site relative to other contamination sites. Ranking of sites is necessary before allocation of state funds for evaluation or final cleanup is made.

2.1 Screening Procedure

Site screening is conducted for each category according to the guidance below and recorded on Figure 1.1. Point allocations are made on the figure according to interpretation tables included in the guidance below. If the category conditions are met, score the points indicated. If the condition is not met, score a 0 for the category. If the condition is suspected but not documented, score a question mark (?) for the category.

Question marks indicate that insufficient information is known about the site and should be used as guidance for further data collection. As the number of question marks entered on the screening form increases, the danger of declaring a false negative for the site increases. A false negative occurs when site risk is underestimated because of a lack of or insufficient information. In the screening system, the false negative would result in a potentially severe site not obtaining the threshold score which qualifies the site for detailed tier 2 scoring and possible allocation of funds for preparation of a feasibility study or final clean-up.

2.1.1 Environmental Contamination

The environmental contamination category evaluates a potential or known contaminant release. A 20 point limit is imposed in order to keep the category from outweighing the points available in the rest of the screening system. The category is divided into four subcategories of increasing severity: potential contamination, known release, environmental impact, and human exposure.

Potential Contamination Subcategory

The potential contamination subcategory evaluates the potential for a contaminant to impact a resource of concern if it were to escape its containment.

<u>Ground Water</u>
If a site overlies an unprotected aquifer so that the aquifer is vulnerable to contamination, score 2 points. Use well logs within a one-half mile radius of the event, the aquifer vulnerability map from the Michigan Surface Impoundment Study, or the Western Michigan University Geological Atlas to estimate vulnerability.

Aquifer vulnerability exists when a confining layer cannot be shown to be continuous among well logs within the one - half mile radius or when defined by the above references.

Surface Water

If a surface water body (stream or lake) lies within one-half mile of a suspected contamination site, score 2 points. However, if the surrounding land topography or elevation restricts the probability of migration of site contaminants to surface water and there is no known drainage from the area (surface or subsurface), the surface water medium should not be scored.

Air

If on-site containers suspected to contain liquids are aging or in danger of failing (for example old and rusting drums), score 2 points. Note that if the containers have failed and are already empty and evidence of stained soils exists, do not score. This situation will be scored under the Suspected Release Subcategory below.

Suspected Release Subcategory

The known release subcategory evaluates an observed or suspected release from a containment structure but contaminant concentrations are not known or there is no apparent negative impact.

Soils

If there has been a release to soils in an area where vegetation is not allowed to grow or in an area where there is vegetation growing but no vegetation impact is observed, score 4 points. This includes stained soils, leaking barrels, or leachate releases. Application of pesticides or fertilizers according to recommended agricultural or silvicultural practices are exempt from consideration unless those practices have resulted in an environmentally hazardous buildup. Evidence for buildup requires soil concentrations and should be scored under Confirmed Contamination below.

Ground Water

If there has been a release to groundwater but the release has not been confirmed by samples documenting contaminant concentration, score 4 points. This includes situations where contaminants have been detected in subsurface soils immediately above the water table but no ground water samples have been collected, gasoline, fuel oil, or other visible contaminants are floating on the ground water, or laboratory analyses have identified compounds in a ground water sample but are unable to quantify contaminant concentrations due to detection limits.

Surface Water

If there is an observed release to surface water not documented by samples identifying the contaminant or concentration, score 4 points. This includes situations where landfill leachate is entering a stream, oil stained soils are observed in contact with surface water, precipitates are observed, or leaking waste containers or spills are in or immediately adjacent to surface water bodies.

Air
If there is an open container or surface impoundment containing known volatile compounds, if an obnoxious or chemical specific odor has been detected in the immediate vicinity of a known point of release, if there has been a release of volatile compounds to soils (this may include stained soils), if a visible emission of dust or particulates is observed from a known contamination area, or if a vapor cloud is observed emanating from a containment structure or known contamination area, score 4 points.

Confirmed Contamination Subcategory

The environmental impact subcategory is scored when there has been a release from a containment structure and environmental samples document that release or there is an observable environmental impact.

Soils
If there has been a release to soils documented by laboratory analysis identifying and quantifying contaminant presence or vegetation has been killed, score 6 points.

Ground Water
If ground water sample results document the identity and concentration of a contaminant in either a water table or confined aquifer, score 6 points.

Surface Water
If surface water or sediment sample results document the identity and concentration of a contaminant in a surface water body (stream or lake), or there has been a documented fish kill, documented fish tissue contamination, or other adverse impact to aquatic life, any one of which is attributable to a documented release, score 6 points.

Air
If air sampling data document the presence of total VOC's or specific contaminants on-site and are being emitted from a known point of release, score 6 points. If an odor, which can be attributed to pollutants present at the site, is detected at the property boundary, score 6 points.

Human Exposure Subcategory

If human exposure has occurred under any of the following conditions, score 8 points for each exposure.

Soils

Score direct contact hazard to humans due to exposure to contaminated soils. In order to score these points, the following conditions must be met. First, hazardous substances must be present in soils at levels twice their background level. Second, there must be a pooling of liquid wastes on the soil surface or wastes must be concentrated at the soil surface. If the contaminated soils are covered by uncontaminated soil or some physical barrier (i.e. a plastic cover or asphalt) human hazard cannot be scored. Third, the contamination area or site is accessible. If the contamination area or site is fenced, human exposure hazard cannot be scored. Site attractiveness may override item three. That is, if site specific conditions indicate that efforts to restrict access have been unsuccessful and the site is unlikely to be secured, the site may be considered to have a direct contact hazard.

Ground Water

Score 8 points if a ground water potable water supply well is contaminated and residents are currently using the affected supply. Score 10 points if 16 or more area private wells or a community water supply system (16 or more connections) are contaminated. If a Public Health Advisory has been issued for a water supply (public or private) score for potable water supply even though bottled water has been provided. Potable water supply is scored because contaminated water may still be used for bathing, cooking, or other purposes and bottled water is not considered a permanent alternate water supply. If a permanent alternate water supply has been provided and the affected supply system has been taken out of service, do not score for drinking water supply contamination.

Surface Water

Score 8 points if a bathing beach or private potable water supply intake exist within the affected area or if a fish advisory has been issued for the water body (and the presence of the contaminants identified in the advisory can be connected to the site). Score 10 points if 16 private intakes or a community water supply system (greater than 16 connections) intake is within the affected area. If a permanent alternate water supply has been provided, note this information on the screening form and do not score for potable water supply contamination. However, if a Public Health Advisory has been issued for a water supply (public or private) and only bottled water has been provided to those affected, score for potable water supply. Drinking water supply is scored because contaminated water may still be used for bathing, cooking, or other purposes and bottled water is not considered a permanent alternate water supply.

Air

For the air compartment, score 8 points for human exposure if air sampling data document the presence of total VOCs or specific contaminants at an off-site receptor (for example a residence), if a chemical odor or any odor which can be attributed to pollutants present at the site is detected at an off-site receptor (the odor must be verified by agency staff), or if off-site soils or other surface sample data indicate volatile or particulate transport off-site has occurred. Score 10 points if 16 or more residences meet any of the above conditions.

2.1.2 Contaminant Mobility

The mobility category assesses the ability of a contaminant to migrate once it has escaped containment. The mobility factors are based upon the same parameters developed in the environmental fate factor portions of Section 5.2. Score one of the two mobility point factors described below if contaminant identity is known.

Ground Water
If organic compounds known to be on-site have a log Kow greater than 4.5 or inorganic compounds are defined as immobile in Table 2.1, do not score any points.

If organic compounds have a log Kow less than 4.5 but equal to or greater than 1.5, or inorganic compounds are defined as moderately mobile in Table 2.1, score 3 points.

If organic compounds known to be on-site have a log Kow of less than 1.5 or inorganic compounds are defined as mobile in Table 2.1, score 6 points.

Surface Water
If the contaminant water solubility is less than 0.01% (100 ppm) or is defined as immobile in Table 2.2, do not score any points.

If compounds known to be on-site have a water solubility of greater than 0.01% (100 ppm) but less than 0.5% (5000 ppm) or are defined as moderately mobile in Table 2.2, score 3 points.

If compounds known to be on-site have a water solubility of greater than 0.5% (5000 ppm) or are defined as mobile in Table 2.2, score 6 points.

Air
If the contaminant vapor pressure is less than 0.002 mm Hg at 20 C do not score any points.

If compounds known to be on-site have a vapor pressure of greater than 0.002 mm Hg at 20 degrees C, but less than 0.1 mm Hg at 20 degrees C, score 3 points.

If compounds known to be on-site have a vapor pressure of greater than 0.1 mm Hg at 20 degrees C, score 6 points.

Unknown Contaminants by Waste Characterization
For unknown contaminants, characterize the site according to its waste type described in Table 2.3. The mobility factors for each

Table 2.1 Ground Water Inorganic Contaminant Mobility Table

pH	Ag	Al	As	B	CN	Cd	Cu	Cr	Hg	Ni	Pb	Se	Zn
4	M	M	M	M	I	M	M	M	M	M	MM	I	M
5	M	M	M	M	I	M	M	M	M	M	MM	I	M
6	MM	M	M	M	I	MM	M	MM	MM	MM	MM	MM	M
7	MM	MM	M	M	I	MM	M	MM	MM	MM	I	M	M
8	I	I	MM	MM	I	I	M	I	I	MM	I	M	MM
9	I	I	I	MM	I	I	M	I	I	I	I	M	MM

M = mobile, MM = moderately mobile, I = immobile

Table 2.2 Surface Water Inorganic Contaminant Mobility Table

	As	CN	Cd	Cu	Cr	Ni	Pb	Zn
Mobility Factor (at pH 5.0)	M	I	M	M	MM	M	MM	M

M = mobile, MM = moderately mobile, I = immobile

Table 2.3 Revised Model Waste Characterization Categories

Level of Concern	Description and Examples	
20	CLASS A (Highest Hazard Potential)	
	Operations producing large amounts of chemical or industrial wastes or products, heavy manufacturing	
	Pharmaceutical Production	Agricultural Chemicals
	Bulk Warehouses	Organic Chemical Prod.
	Explosives	Dyes and Pigments
	Wood Treatment	Chemical Formulation
	Plating Shops	Heavy Metals Prod.
	Printed Circuits	Monomer Synthesis
	Polymer Synthesis	Chemical Treating
	Chemical Coating	Chemical Bonding
	Oil Paint Prod.	Large Assembly Plants
15	CLASS B (Secondary Hazard Potential)	
	Operations producing moderate amounts of chemical or industrial wastes or products, light manufacturing	
	Primary Metals Production	Rubber Products Prod.
	Small Assembly Plants	Battery Production
	Inorganic Chemical Production (non-heavy metals)	
	Sealant Production	Clay/Glass Production
	Bodywork and Paint Shops	Soap and Detergent Prod.
	Pulp and Paper Production (chlorine bleaching)	
10	CLASS C (Moderate Hazard Potential)	
	Operations with low chemical use and disposal needs	
	Product Assembly	Plastics Fabrication
	Plastics Molding	Metal Stamping
	Machining	Auto Repair (non paint)
	Aircraft Assembly	Boat Assembly
	Latex Paint Production	Medical/Hospital Wastes
	Pharmaceutical Formulation	Soap and Detergent Form.
	Laboratory Waste	Consumer Packaging
	Cleaning Transport Vehicles	
	Pulp and Paper Production (no chlorine bleaching)	
	Coal Ash or Foundry Sands (EP Toxic, hazardous)	
5	CLASS D (Low Hazard Potential)	
	Operations producing or disposing of domestic or commercial wastes in household level quantities	
	Coal Ash or Foundry Sand (non EP Toxic, non hazardous)	
0	CLASS E (Wastes Regarded As Inert)	
	Wastes defined as inert by Act 641 of the Public Acts of 1978 or its rules	

waste category are presented by medium type in Table 2.4. Score 6 points for a mobile designation, 3 points for a moderately mobile designation, and 0 points for the immobile designation. The derivation of the waste characterization method of mobility evaluation is explained in Section 5.2.

Special Conditions, All Media

If on-site contaminants have been identified as gasoline or fuel oil, consider them mobile for ground water, surface water and air and score 6 points. However, if the release has occurred underground rather than at or near the soil surface (deeper than 6 inches for clayey or loam soils or deeper than 1 foot for sand or gravely soils), consider them immobile for the surface water and air categories.

For all media (ground water, surface water and air) develop a weighted average mobility factor for all contaminants if there is more than one contaminant on-site.

- For organic compounds, multiply each compound log Kow, water solubility, or vapor pressure value by the quantity of waste, sum these values for all compounds and divide by the total quantity of organic waste on site. Do not include any quantity of waste defined as immobile in the total waste quantity. If the weighted average log Kow is greater than 4.5, the water solubility is greater than 0.5% (5000 ppm), or the vapor pressure is greater than 0.1 mm Hg, define the contaminant group as mobile and score 6 points. If the weighted average log Kow is less than 4.5, the water solubility is less than 0.5% (5000 ppm), or the vapor pressure is less than 0.1 mm Hg define the contaminant group as moderately mobile and score 3 points.
- For inorganic compounds, assign the moderately mobile or mobile classification appropriate to each contaminant, assign a value of 3 to moderately mobile compounds or 6 to mobile compounds, multiply this mobility factor for each compound by its quantity of waste on site, sum all compound values and divide by the total quantity of inorganic waste on site. Do not include any quantity of waste defined as immobile in the total waste quantity. If the weighted average inorganic value is 1.6 or greater, define the contaminant group as mobile and score 6 points. If the average value is equal to or below 1.5, define the contaminant group as moderately mobile and score 3 points.
- For a combination of organic and inorganic compounds, group the organic and inorganic compounds separately, develop a weighted average mobility score for each group according to the weighting methods above, multiply the quantity of waste in each group by the mobility points for the group, sum the two group weighted values and divide by the total quantity of waste on site. Do not include any quantity of waste defined as immobile in the total waste quantity. If the resulting average value is 1.6 or greater, define the waste on site as

Table 2.4 Contaminant Mobility of Waste Types by Environmental Medium

	Waste Type Category				
Environmental Medium	A	B	C	D	E
Ground Water	MM	MM	M	M	I
Surface Water	MM	M	M	M	I
Air	M	MM	M	MM	I

M = mobile, MM = moderately mobile, I = immobile

mobile and score 6 points. If the resulting average value is equal to or less than 1.5, define the waste on site as moderately mobile and score 3 points.

-If there is a combination of known compounds and unknown compounds (which require evaluation by waste characterization) on site, assign a value of 2 to wastes characterized as mobile and a value of 1 to wastes characterized as moderately mobile, and develop a weighted average score in the same manner as described above in the combination of organic and inorganic compounds. Do not assign any value to wastes characterized as immobile and do not include any quantity of waste defined as immobile in the total waste quantity.

2.1.3 Sensitive Environment

If a sensitive environmental resource is located within one-half mile of a known or suspected contamination site, score 3 points. A sensitive environment is defined as a wetland, valuable timber resource, or parkland. A wetland is further defined as land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life and is commonly referred to as a bog, swamp, or marsh. The wetland or timber resource must be equal to or greater than 5 acres in size. Exceptions to the 5 acre limit are wetlands known to be spawning areas critical to fisheries populations or contiguous with surface water bodies, habitats known to be used by or comprised of threatened or endangered species, lands designated as wildlife or game management areas or, designated wilderness areas. If the topography or land elevation of the Sensitive Environment is higher than the site and the probability of exposure or contaminant migration to the sensitive environment is low, the points should not be scored.

2.1.4 Population

If there are less than 100 people in a one square mile area (radius of 0.56 mi.) immediately surrounding the site, do not score any points.

If there are between 101 and 500 people per square mile within a one-half mile radius of the site, score one point.

If there are between 501 and 2500 people per square mile within a one-half mile radius of the site, score 3 points.

If there are more than 2500 people per square mile within a one-half mile radius of the site, score 5 points.

Seasonal or daily work force populations should be included in the above population ranges. Populations may be estimated from aerial photographs, assuming four people per home. Topographic maps should not be used for making population estimates. A site within any limits of an incorporated city, village or town (within the pink shaded areas on a topographic map) is assumed to meet the 100 people per square mile criterion. If more than 100 people have been directly affected by a contamination incident, score one point even though the population density does not appear to exceed this criterion (for example, where a public water supply system has been contaminated).

2.1.5 Institutional Population

If a school, hospital or nursing home is within one-half mile of the site, score an additional maximum of 1 point.

2.1.6 Contaminant Concern

Toxicity/Quantity of Concern is scored directly from the tables in Figure 1.1. Scoring may be done either for known contaminants or unknown contaminants. Known contaminants are scored using the potential toxicity score available on a chemical by chemical basis in Table 2.5. Unknown contaminants are assessed by waste type characterization. Classify the waste material source according to the waste category type table in Table 2.3 and enter Figure 2.1 with that classification against the total mass of contaminant.

If more than one contaminant has been discovered at the site, develop a weighted average for the potential toxicity scores of the known compounds and enter the table with that average against the total mass of contaminant. The weighted average is derived by multiplying each contaminant potential toxicity score Table 2.5 by the quantity of contaminant on site, summing these values and dividing by the total quantity of waste on site. The contaminants do not need to be on the Michigan Critical Materials Register to have a Potential Toxicity Score or to be scored.

If contaminants have been identified as gasoline or fuel oil, assume a potential toxicity score of 21 (derived from O'Dell's scoring method, Chapter 3.1). If the quantity of gas or fuel loss is unknown, assume 1) a 300 gallon loss if no likely source of contamination has been identified within 1/2 mile of the site or a small volume loss involving a spill, accident or truck to tank transfer has occurred, or 2) a 3000 gallon loss if there have been allegations or known loss from a commercial underground storage tank or if large capacity tanks are known to exist within 1/2 mile of the contamination site.

If a combination of identified and unidentified contaminants are on site so that both Toxicity/Quantity of Concern methods must be applied, a weighted average score must be derived for the category. The weighted average should be derived by multiplying the identified contaminant concern score by the total quantity of identified contaminants on site, multiplying the waste type characterization concern score by the quantity of unidentified contaminants on site, summing the resulting values and dividing by the total quantity of waste on site.

Table 2.5 Contaminant Potential Toxicity Factors and Physical Constants

CHEMICAL	CAS #	POT. TOX.	DATE SCORED	ON CMR	CA	WATER SOLUBILITY	log KOW	VAPOR PRESS
Acetone	67-64-1	15.0	1-87	No	No	1.00E+06	-0.24	2.70E+02
Acrolein	107-02-8	22.0	1-86	Yes	No	1.44E+06	0.10	2.20E+02
Acrylonitrile	107-13-1	37.5	1-87	Yes	Yes	1.01E+06	0.25	1.00E+02
Aflatoxin	1402-68-2	52.5	7-87	Yes	Yes			
Aldicarb	116-06-3	30.0	9-84	Yes	No	6.00E+03	1.57	4.10E-01
Aluminum (nitrate)	7429-90-5	22.5	9-84	No	No	6.37E+05	NA	NA
Aniline	62-53-3	30.6	1-87	Yes	Yes	3.40E+04	0.90	3.00E-01
Arsenic	Class-01-1	66.0	1983	Yes	Yes			0.00E+00
Asbestos	1332-21-4	45.0	7-87	Yes	Yes	NA	NA	NA
Barium	7440-39-3	18.0	1983	No	No	3.75E+05	NA	NA
Benzene	71-43-2	67.5	1983	Yes	Yes	1.75E+03	2.12	9.52E+01
1,2-Benzenedicarboxylic acid	17851-53-5	30.0	7-82	No	No	5.40E+02	0.41	
Benzidine	92-87-5	45.0	12-86	Yes	Yes	4.00E+02	2.12	5.00E-04
Benz(a)anthracene	56-55-3	37.5	8-86	Yes	Yes	5.70E-03	5.60	2.20E-08
Benzo(b)Fluoranthene	205-99-2	18.0	9-84	No	Yes	1.40E-02	6.06	5.00E-07
Benzo(k)Fluoranthene	207-08-9	18.0		No	Yes	4.30E-03	6.06	5.10E-07
Benzoic Acid	65-85-0	1.8		No	No	2.90E+03	1.87	
Benzoperylene	191-24-2	1.8		No	No	2.66E-04	7.10	
Benzo(a)pyrene	50-32-8	60.0	1-85	Yes	Yes	1.20E-03	6.06	5.60E-09
Bis(2-chloroethoxy)ethane	112-26-5	9.0	9-84	No	No	1.30E-02	1.06	3.80E-01
Bis(2-chloroethoxy)methane	111-91-1	1.8	9-84	No	No	1.20E-02	0.75	2.00E-02
Bis(1-chloroethyl)ether	6986-48-7	1.8	10-84	No	No			
Bis(2-chloroethyl)ether	111-44-4	24.0	9-84	Yes	No	1.02E+04	1.5	7.10E-01
Bis(2-chloro-1-methylethyl)ether	108-60-1	27.0	10-84	No	No	1.70E+03	2.1	8.50E-01
Bis(2-ethylhexyl)pthalate	117-81-7	48.0	1983	Yes	Yes	2.70E-03	8.66	1.00E-02
Bromochloromethane	74-97-5	9.0	9-84	No	No	9.00E+03	1.41	1.17E+02
Bromodichloromethane	75-27-4	24.0	9-84	No	No	4.30E+03	2.08	5.00E+01
Bromoform	75-25-2	22.5	6-84	No	No	3.00E+03	2.36	5.60E+00
Bromotrichloromethane	72-62-7	9.0	11-84	No	No			
n-butane	106-97-8	0.0	1983	No	No	2.90E+02	2.81	1.82E+03
Butyl-benzyl-phthalate	85-68-7	7.5	1983	No	No	2.90E+00	4.87	8.60E-06
t-butyl alcohol	75-65-0	1.8	10-84	No	No	7.90E+04	0.37	3.10E+01
Cadmium	7440-43-9	84.0	1983	Yes	No		NA	NA
Cadmium chloride	10108-64-2	42.0	12-84	Yes	No	1.40E+06	NA	NA
Calcium carbide	75-20-7	6.0	1983	No	No	decompose	NA	NA
Calcium carbonate	1317-65-3	0.0	1983	No	No	1.40E+01	NA	NA
Calcium oxide	1305-78-8	6.0	1983	No	No	decompose	NA	NA
Carbontetrachloride	56-23-5	24.0	1-87	Yes	Yes	7.57E+02	2.64	9.00E+01
Chlordane	57-74-9	52.5		Yes	Yes	5.60E-01	3.32	1.00E-05
Chlorine	7782-50-5	48.0	1983	Yes	No			
4-chloro-3-methyl phenol	59-50-7	1.8	7-84	No	No	1.30E+02	3.10	1.00E-02
Chlorobenzene	108-90-7	37.5	9-84	Yes	Yes	4.66E+02	2.84	1.17E+01
Chlorodibromomethane	124-48-1	18.0	9-84	No	No	2.30E+03	2.09	1.50E+01
Chlorodifluoromethane	75-45-6	9.0	12-84	No	No	2.40E+04	1.08	3.50E+03
Chloroethane	75-00-3	9.0	9-84	No	No	5.74E+03	1.54	1.06E+03
2-Chloroethoxyethene	110-75-8	7.5	9-84	No	No	1.50E+04	1.28	2.67E+01
Chloroform	67-66-3	36.0	1986	Yes	Yes	8.20E+03	1.97	1.51E+02
Chlorotrifluoromethane	75-72-9	1.8	12-84	No	No	9.50E+03	1.65	
1-Chlorophenoxybenzene	7005-72-3	27.0	8-84	Yes	No	3.30E+00	5.09	2.70E-03

Table 2.5 (cont'd.)

CHEMICAL	CAS #	POT. TOX.	DATE SCORED	ON CMR	CA	WATER SOLUBILITY	log KOW	VAPOR PRESS
Chromium	7440-47-3	54.0	1983	Yes	No	very sol.	NA	NA
Chromium tri-oxide	1333-82-0	72.0	1983	Yes	No	6.17E+05	NA	NA
Chrysene	218-01-9	18.0		No	Yes	1.80E-03	5.61	6.30E-09
Cobalt	7440-48-4	37.5	12-85	Yes	No	4.50E+05	NA	NA
Copper	7440-50-8	37.5	1983	Yes	No	7.06E+05	NA	NA
Creosote	8001-58-9	22.5	9-84	No	No			
Cresyl diphenyl phosphate	26444-49-5	9.0	4-86	No	No		4.50	
Crystal violet	548-62-9	22.5	8-86	No	No			
Cumene	98-82-8	15.0	9-84	No	No	5.00E+01	3.66	8.00E+00
Cyanide (cyanogen)	460-19-5	45.0	1983	Yes	No	2.50E+05		
Cyclohexane	110-82-7	7.5	1983	NO	No	1.20E+02	3.35	7.20E+01
p,p-DDT	50-29-3	54.0	10-84	Yes	Yes	2.00E+02	6.91	5.10E-01
o,p-DDT	789-02-6	27.0	10-84	Yes	No			
p,p-DDE	72-55-9	37.5	10-84	Yes	Yes	4.00E-02	7.00	6.50E-06
p,p-DDD	72-54-8	42.0	10-84	Yes	Yes	1.00E-01	6.20	1.89E-06
1,2-Dibromoethane (ethylene dibromide)	106-93-4	48.0	1983	No	Yes	4.31E+03	1.74	1.40E+01
Di-n-butylphthalate	84-74-2	15.0	1983	Yes	No	1.30E+01	4.69	1.00E-05
1,2-Dichlorobenzene	95-50-1	15.0	9-84	Yes	No	1.00E+02	3.60	1.00E+00
1,3-Dichlorobenzene	541-73-1	9.0	9-84	No	No	1.23E+02	3.60	2.28E+00
1,4-Dichlorobenzene	106-46-7	22.5	9-84	Yes	Yes	7.90E+01	3.60	1.18E+00
3,3-Dichlorobenzidine	91-94-1	22.5	12-84	Yes	Yes	1.50E+02	3.50	1.00E-02
Dichlorodifluoromethane	75-71-8	1.8	12-84	No	No	2.80E+02	2.16	4.87E+03
1,1-Dichloroethane	75-34-3	1.8	10-84	No	No	5.50E+03	1.79	1.82E+02
1,2-Dichloroethane	107-06-2	36.0	4-86	Yes	Yes	8.52E+03	1.48	6.40E+01
1,1-Dichloroethylene	75-35-4	24.0	9-84	Yes	Yes	2.25E+03	1.84	6.00E+02
cis-1,2-dichloroethylene	156-59-2	1.8	10-84	No	No	3.50E+03	0.70	1.68E+02
1,2-Dichloroethylene (cis and trans)	540-59-0	1.8	10-84	No	No	6.30E+03	1.51	2.64E+02
trans-1,2-dichloroethylene	156-60-5	7.5	10-84	No	No	6.30E+03	1.51	3.24E+02
Dichlorofluoromethane	75-43-4	1.8	12-84	No	No	1.02E+04	1.51	1.52E+03
2,4-Dichlorophenol	120-83-2	9.0	12-85	Yes	No	2.80E+02	2.90	1.50E-01
1,1-Dichloropropane	78-99-9	9.0	11-84	No	No		2.30	4.80E+01
1,2-Dichloropropane	78-87-5	45.0	11-84	No	Yes	2.70E+03	2.00	4.20E+01
1,3-Dichloropropane	142-28-9	9.0	11-84	No	No	7.13E+03	2.00	1.45E+01
2,2-Dichloropropane	594-20-7	1.8	11-84	No	No		2.34	
cis-1,2-dichloropropene	6923-20-2	1.8	8-84	No	No		2.07	
cis-1,3-dichloropropene	10061-01-5	9.0	8-84	No	No	7.32E+03	1.98	1.88E+01
trans-1,2-dichloropropene	7069-38-7	1.8	8-84	No	No		2.07	
trans-1,3-dichloropropene	10061-02-6	9.0	8-84	No	No	7.32E+03	1.98	1.88E+01
1,1-Dichloropropene	563-58-6	1.8	8-84	No	No	3.84E+02	2.67	1.88E+01
1,2-Dichloropropene	563-54-2	1.8	8-84	No	No	2.70E+03	2.04	4.00E+01
1,3-Dichloropropene	542-75-6	20.0	8-84	Yes	No	2.80E+03	2.00	2.50E+01
2,3-Dichloropropene	78-88-6	15.0	8-84	No	No	4.73E+03	1.98	5.30E+01
3,3-Dichloropropene	563-57-5	1.8	8-84	No	No	4.62E+03	1.76	1.80E+01
Dieldrin	60-57-1	78.0		Yes	Yes	1.95E-01	3.50	1.78E-07
Diethylphthalate	84-66-2	15.0	9-84	No	No	1.93E+03	2.50	1.00E-02
Diethylhexylphthalate	117-81-7	48.0	11-84	No	Yes	2.76E-03	8.66	1.00E-02
Diisopropyl ether	108-20-3	7.5	9-84	No	No	1.07E+04	1.74	1.19E+02
N,N-dimethylaniline	121-69-7	18.0	1983	No	No	1.79E+03	2.31	5.00E-01
Dimethyl mercury	593-74-8	9.0	8-84	Yes	No			

Table 2.5 (cont'd.)

CHEMICAL	CAS #	POT. TOX.	DATE SCORED	ON CMR	CA	WATER SOLUBILITY	log KOW	VAPOR PRESS
Dimethyl phthalate	131-11-3	18.0	8-84	No	NO	1.89E+04	1.51	1.00E-02
Dimethylphenol	1300-71-6	9.0	12-85	No	No			
2,3-Dimethylphenol	526-75-0	1.8	12-85	No	No	2.17E+02	2.77	2.00E-02
2,4-Dimethylphenol (2,4-xylenol)	105-67-9	9.0	12-85	No	No	6.70E+02	2.77	2.60E-01
2,5-Dimethylphenol (2,5-xylenol)	95-87-4	1.8	12-85	No	No	2.12E+02	2.33	1.30E-01
2,6-Dimethylphenol	576-26-1	9.0	12-85	No	No	4.23E+02	2.36	2.10E-01
3,4-Dimethylphenol	95-65-8	9.0	12-85	No	No	2.79E+02	2.16	1.00E-02
3,5-Dimethylphenol	108-68-9	9.0	12-85	No	No	2.73E+02	2.35	2.00E-02
2,6-Dinitro-p-cresol	609-93-8	1.8	10-84	No	No	4.64E+02	2.56	
4,6-Dinitro-o-cresol	534-52-1	30.0	10-84	Yes	No	2.90E+02	2.70	5.00E-02
Dinitrotoluene	25321-14-6	30.0	11-84	Yes	No			
2,3-Dinitrotoluene	602-01-7	22.5	11-84	Yes	No	3.10E+03	2.29	
2,4-Dinitrotoluene	121-14-2	30.0	11-84	Yes	Yes	2.04E+03	2.00	5.10E-03
2,5-Dinitrotoluene	619-15-8	15.0	11-84	Yes	No	1.32E+03	1.99	
2,6-Dinitrotoluene	606-20-2	24.0	11-84	Yes	No	1.32E+03	2.00	1.80E-02
3,4-Dinitrotoluene	610-39-9	15.0	11-84	Yes	No	1.08E+03	2.29	
Di-n-octylphthalate	117-84-0	22.5	1983	Yes	No	1.52E-03	8.29	
Dinoseb	88-85-7	42.0	8-84	Yes	Yes	5.00E+01	4.02	
1,4-Dioxane	123-91-1	18.0	1-86	Yes	Yes	4.31E+05	-0.49	3.99E+01
2,3-Epoxy-1-propanal (Glycidol)	765-34-4	22.5	1-86	No	Yes		1.99	9.00E-01
Ethyl alcohol (ethanol)	64-17-5	7.5	10-84	No	No	2.58E+05	-0.32	7.40E+02
N-ethylanaline	103-69-5	9.0	1983	No	No	2.65E+03	2.17	3.60E-01
Ethylbenzene	100-41-4	22.5	1983	No	No	1.52E+02	3.15	7.00E+00
Ferric sulfate	10028-22-5	1.8	1983	No	No	sl. sol.	NA	NA
Ferrous oxide	1309-37-1	12.0	1983	No	No	insol.	NA	NA
Fluoranthene	206-44-0	18.0		No	No	1.00E+00	4.90	5.00E-06
Fluorene (a-diphenylene methane)	86-73-7	36.0	1983	No	No	1.69E+00	4.20	7.10E-04
Heptachlorostyrene (general)	61255-81-0	1.8	5-84	No	No			
Hexachlorobenzene (C-66)	118-74-1	52.5	12-84	Yes	Yes	6.00E-03	6.42	1.09E-05
Hexachlorobutadiene (C-46)	87-68-3	48.0	12-84	Yes	Yes	4.20E+01	4.74	2.30E-01
Hexachlorocyclopentadiene	77-47-4	37.5	12-84	Yes	No	1.98E+01	5.04	8.00E-02
Hexachloroethane	67-72-1	42.0	1-87	Yes	Yes	4.50E-01	4.14	4.00E-01
Hexachlorostyrene (general)	61128-00-5	1.8	8-86	No	No			
n-hexane	110-54-3	0.0	1983	No	No	7.55E+01	3.87	1.20E+02
Hydroquinone	123-31-9	24.0	2-87	Yes	No	1.96E+03	0.81	
4-hydroxy-4-methyl-2-pentanone	123-42-2	1.8	11-83	No	No	4.73E+05	-0.10	1.00E+00
Indene	95-13-6	9.0	9-84	No	No	3.75E+02	2.92	9.50E-01
Indeno(1,2,3-cd) pyrene	193-39-5	18.0		No	Yes	9.80E-03	6.58	1.00E-02
Isopentane	78-78-4	0.0	1983	No	No	4.80E+01	3.21	5.69E+02
Isopropylphenyldiphenylphosphate	28108-99-8	9.0	4-86	No	No		5.30	
Kerosene	8008-20-6	22.5	8-86	No	No			
Lead	Class-01-9	72.0	1983	Yes	No	9.90E+03	NA	NA
Lindane	58-89-9	54.0		No	Yes	1.20E+01	3.70	9.40E-06
Manganese	7439-96-5	54.0	1983	No	No	7.23E+05	NA	NA
Mercury	7439-97-6	84.0	1983	Yes	No	6.90E+04	NA	2.00E-03
Methoxychlor	72-43-5	15.0		Yes	No	4.00E-02		
Methyl bromide (Bromomethane)	74-83-9	30.0	11-84	Yes	Yes	2.55E+05	1.07	1.25E+03
Methyl-t-butyl ether	1634-04-4	15.0	7-87	No	No	2.54E+03	1.3	1.97E+02
Methyl chloride	74-87-3	45.0	1983	Yes	Yes	1.87E+04	0.95	4.31E+03

Table 2.5 (cont'd.)

CHEMICAL	CAS #	POT. TOX.	DATE SCORED	ON CMR	CA	WATER SOLUBILITY	log KOW	VAPOR PRESS
Methylene chloride	75-09-2	22.5	9-84	Yes	Yes	2.00E+04	1.24	3.49E+02
Methylethyl ketone (2-butanone)	78-93-3	15.0	1983	No	No	2.68E+05	0.26	7.75E+01
1-Methylnapthalene	90-12-0	9.0	6-86	No	No	2.70E+01	3.87	6.00E-02
Mineral spirits	8052-41-3	9.0	9-84	No	No			
Naphthalene	91-20-3	15.0	1-87	No	No	5.46E+01	3.32	8.20E-02
Nickel	7440-02-0	78.0	1983	Yes	No	6.42E+05	NA	NA
m-Nitrophenol	554-84-7	12.0	1-85	No	No	1.21E+03	2.00	3.30E-01
Nitrate-nitrogen		6.0	1983	No	No			
Nitrobenzene	98-95-3	15.0	6-84	Yes	No	1.90E+03	1.88	1.50E-01
o-Nitrophenol	88-75-5	12.0	1-85	No	No	2.10E+03	1.85	1.20E-01
p-Nitrophenol	100-02-7	20.0	1-85	No	No	1.60E+01	2.08	
Octachlororocyclopentane (C-58)	706-78-5	1.8	12-84	No	No			
Octachlorostyrene	29082-74-4	27.0	5-84	Yes	No		6.29	
1,1-Oxybisbenzene (phenyl ether)	101-84-8	1.8	1983	No	No	2.35E+01	4.20	2.00E-02
Pentachlorophenol	87-86-5	36.0	10-84	Yes	No	2.42E-01	5.00	1.10E-04
Pentachloronitrobenzene	82-68-8	37.5	9-85	Yes	Yes	7.95E-01	5.45	1.13E-04
Polybrominated biphenyls (PBB)	Class-07-8	30.0	1983	Yes	No			
Polychlorinated biphenyls (PCB)	Class-07-9	78.0	1983	Yes	Yes	3.10E-02	6.04	7.70E-05
n-Pentane	109-66-0	7.5	1983	No	No	1.07E+02	3.37	4.30E+02
Phenanthrene	85-01-8	22.5	1-84	No	No	3.31E+02	4.46	6.80E-04
Phenol	108-95-2	18.0	9-84	Yes	No	6.81E+03	1.46	3.41E-01
Pyrene	129-00-0	18.0	1983	No	No	1.32E-01	4.88	2.50E-06
Selenium (oxide)	7782-42-2	60.0	1983	Yes	No	3.84E+05	NA	NA
Silver	7440-22-4	48.0	1983	Yes	No	8.90E-01	NA	NA
Sodium chloride	7647-14-5	0.0	1983	No	No	3.57E+05	NA	NA
Sodium floride	7681-49-4	37.5	1983	No	No	4.22E+04	NA	NA
Styrene	100-42-5	30.0	1983	Yes	Yes	3.00E+02	3.16	5.00E+00
Terbufos	13071-79-9	37.5	11-84	Yes	No	1.50E+01		2.60E-04
2,3,6,7-Tetrachlorobiphenylene	7090-41-7	1.8	1-85	No	No			
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	72.0	11-84	No	No		6.90	
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	54.0		No	No		5.82	2.00E-06
Tetrachloroethylene (PCE)	127-18-4	30.0	12-84	No	Yes	1.50E+02	2.60	1.78E+01
Tetrahydrofuran	109-99-9	7.5	1-86	No	No	1.09E+05	0.32	1.32E+03
Thallium	7440-28-0	42.0	1983	No	No	2.90E+03	NA	NA
Titanium dioxide	13463-67-7	6.0	1983	No	No	insol.	NA	NA
Toluene (methylbenzene)	108-88-3	30.0	12-86	Yes	No	5.35E+02	2.73	2.81E+01
Toxaphene	8001-35-2	45.0	12-84	Yes	Yes	5.00E-01	3.30	4.00E-01
Tributyltin oxide	56-35-9	30.0	6-86	Yes	No			
Triaryl phosphate esters	Class 08-4	9.0	4-86	Yes	No			
Trichlorobenzene	12002-48-1	37.5	9-84	No	No			
1,2,3-Trichlorobenzene	87-61-6	27.0	9-84	Yes	No	1.20E+01	4.28	2.00E-02
1,2,4-Trichlorobenzene	120-82-1	22.5	9-84	Yes	No	3.00E+01	4.30	2.90E-01
1,3,5-Trichlorobenzene	108-70-3	18.0	9-84	No	No	5.80E+00	4.28	1.60E-01
1,1,1-Trichloroethane	71-55-6	18.0	9-84	No	No	1.50E+03	2.50	1.23E+02
1,1,2-Trichloroethane	79-00-5	30.0	11-84	Yes	Yes	4.50E+03	2.47	3.00E+01
Trichloroethylene (TCE)	79-01-6	36.0	1986	Yes	Yes	1.10E+03	2.38	5.79E+01
Trichlorofluoromethane	75-69-4	1.8	12-84	No	No	1.10E+03	2.53	6.67E+02
2,4,5-Trichlorophenol	95-95-4	15.0	10-86	Yes	Yes	3.40E+01	3.72	0.00E+00
2,4,6-Trichlorophenol	88-06-2	30.0	3-86	Yes	Yes	6.10E+01	3.87	1.20E-02

Table 2.5 (cont'd.)

CHEMICAL	CAS #	POT. TOX.	DATE SCORED	ON CMR	CA	WATER SOLUBILITY	log KOW	VAPOR PRESS
Tricresyl phosphate	1330-78-5	9.0	4-86	No	No		5.90	
Tri-m-cresyl phosphate	563-04-2	1.8	4-86	No	No	3.13E-01	6.58	3.00E-02
Tri-o-cresyl phosphate	78-30-8	7.5	4-86	No	No	3.13E-01	6.58	1.70E-06
Tri-p-cresyl phosphate	78-32-0	1.8	4-86	No	No	7.40E-02	6.58	0.00E+00
1,2,4-Trimethylbenzene	95-63-6	1.8	1983	No	No	3.16E+01	4.09	1.76E+00
Triphenyl phosphate	115-86-6	22.5		No	NO	1.36E+01	4.60	<0.1
Trixylyl phosphate	25155-23-1	1.8	4-86	No	No		5.26	
Urethane	51-79-6	36.0	1-85	Yes	Yes	2.53E+05	-0.15	5.60E-01
Vinyl chloride	75-01-4	22.5	9-84	Yes	Yes	2.67E+03	1.38	2.66E+03
Vinylidenechloride(1,1-Dichloroethylene)	75-35-4	24.0	1984	No	Yes	2.44E+03	2.10	5.00E+02
Xylene (mixed)	1330-20-7	15.0	1983	Yes	No	1.98E+02	3.26	1.00E+01
Zinc	7440-66-6	30.0	1983	Yes	No	4.32E+06	NA	NA

All of the elemental metals, unless otherwise noted, are given the value of a chloride salt for water solubility.

2.2 Final Total Screen Score

Note that the number of points available in the known environmental contamination category is not to exceed 20 points, nor 15 points in the Toxicity/Quantity Concern Category. Add the points assigned to each category to obtain the total score (Maximum 50 points). Question marks are added at one-half the maximum category score. If a total score consists of some number and one-half because question marks were included, round the screen score up to the nearest whole number. Interpret the screening system score in terms of the threshold and guidance in Section 2.1.

3.0 Waste Quantification

Selection of the waste quantification method for scoring Migration Potential and Chemical Hazard for a site should be done according to the following hierarchy: 1) known source, contaminants and quantities or calculated quantities, 2) known source, waste characterization and containment size, and 3) unknown source but known contaminants and concentrations.

(A known source is defined as the location of waste material which has released the contaminant(s) in question or which may release hazardous materials to the environment due to inadequacy of containment to prevent that potential release.)

Method 1 Known source, Contaminants and Quantities or Calculated Quantities

When all contaminants and quantities are known, simple tabulation of the data is done using Figure 3.1. The final waste quantity must be recorded on Figures 5.1 and 5.2. Quantities may be derived from records of total waste disposed at the site or direct measurement of contaminant concentration according to the options below.

-Option 1 The contaminant is identified and the pure product quantity is recorded in kg.

-Option 2 If the volume of the containment structure and concentration data are available, calculate the quantity of pure contaminant for entry into Figure 3.1.

-Option 3 Where ground water is known to be contaminated but the depth of contaminantion is unknown, assume the entire aquifer thickness is contaminated. An estimate of the areal extent of the plume must also be obtained. For the water table aquifer, this includes the thickness between the water table level and the underlying confining layer. For the confined aquifer, this means the thickness of water bearing material between the overlying and underlying confining layers. When the depth to the underlying confining layer is not known, the confined aquifer thickness cannot be estimated: there is no default value for aquifer thickness.

-Option 4 When the contaminants have been identified but quantities are known only by number of drums (concentration data are missing), cubic yards or other similar measurements, apply the characterization techniques in Method 2.

Method 2 Known Source, Waste Characterization and Containment Size

Unknown contaminants are addressed by characterization of the waste according to its generation source. The waste is characterized using Table 2.3 and the containment size is recorded. If a landfill is known to have accepted more than one class of waste, apportion the

IDENTIFIED CHEMICALS				
Containment Structure	Contaminant	PTF	Contaminant Quantity	Chemical Hazard Score A

WASTE CHARACTERIZATION			
	(Unidentified Chemicals)		
Containment Structure	Waste Category (Class)	Waste Quantity	Chemical Hazard Score B

TOTAL CHEMICAL HAZARD SCORE (Maximum Score = 1300)	

(Individual Chemical or Class Score Maximum = 1000)

A $CH_{ID\ Contam} = PTF(Q^{0.5})$

B $CH_A = PTF(Q_A^{0.5})$, $CH_B = PTF(Q_B^{0.5})$, $CH_C = PTF(Q_C^{0.5})$, $CH_D = PTF(Q_D^{0.5})$

Figure 3.1 Contaminant Identification, Quantification, and Chemical Hazard Score Worksheet waste quantities among the waste classes using known or estimated ratios. If ratios are not known or estimated apply equal proportions among waste types.

Method 3 Unknown Source and Quantities, but Known Concentration

Apply this method only when contamination has been detected but the contaminant source is not known. Generally, scoring can only be accomplished for the affected compartment. However, if more than one compartment is contaminated or if contamination in one compartment has migrated to another, additional affected compartments may be scored. This method assesses the concentration of documented contaminants in the environment. Concentration data from contaminated wells or other environmental samples are required. The concentration data are applied directly in Chemical Hazard.

4.0 Chemical Hazard Compartment

The Chemical Hazard category assesses the inherent toxicity (Potential Toxicity Factor) and quantity of the contaminants identified at a site. It integrates these characteristics in an equation to determine the chemical hazard score.

The human health and environmental hazards are evaluated via the criteria and rationale developed for the Michigan Critical Materials Register (CMR) and are expressed as Potential Toxicity Factors.

Method 1 Specific Contaminants Hazard Scoring

The relationship between chemical hazard score, waste quantity, and Potential toxicity Factor for identified contaminants is shown in Figure 4.1.

1. Determine the identity and quantity (measured or estimated) of those specific contaminants on site (Figure 3.1).

2. Obtain the Potential Toxicity Score from Table 2.5 for each contaminant (measured or estimated) to be present at quantities of 1 kg or greater (as identified chemical). An exception to this procedure are severely toxic materials; (2,3,7,8-tetrachlorodibenzo-p-dioxin, 1,2,3,7,8-pentachlorodibenzo-p-dioxin, 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin, 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin, 2,3,7,8-tetrachlorodibenzofuran, and 1,2,3,7,8-pentachlorodibenzofuran; which need to be handled as special wastes. For these severely toxic materials, a ≥ 1 ppb chemical concentration or ≥ 1 kg of total chemicals (whatever are detected) will be considered for scoring.

3. Calculate the Chemical Hazard score for each identified contaminant using the equation:

$$CH = PTF(Q^{0.5})$$

Where CH is the Chemical Hazard Score, PTF is the Potential Toxicity Factor, and Q is the contaminant quantity. The maximum score obtainable for each individual contaminant is 1000 points. Record the score for each contaminant on Figure 3.1.

4. To calculate the total known chemical hazard score for the site, add the individual identifiable chemical hazard scores, the sum of which is the hazard score for those identified contaminants on site. Record the total on Figure 3.1. Note that the maximum score for all contaminants cannot exceed 1300 points.

Method 2 Waste Characterization Hazard Scoring

The relationship between chemical hazard score, waste quantity, and waste characterization is shown in Figure 4.2.

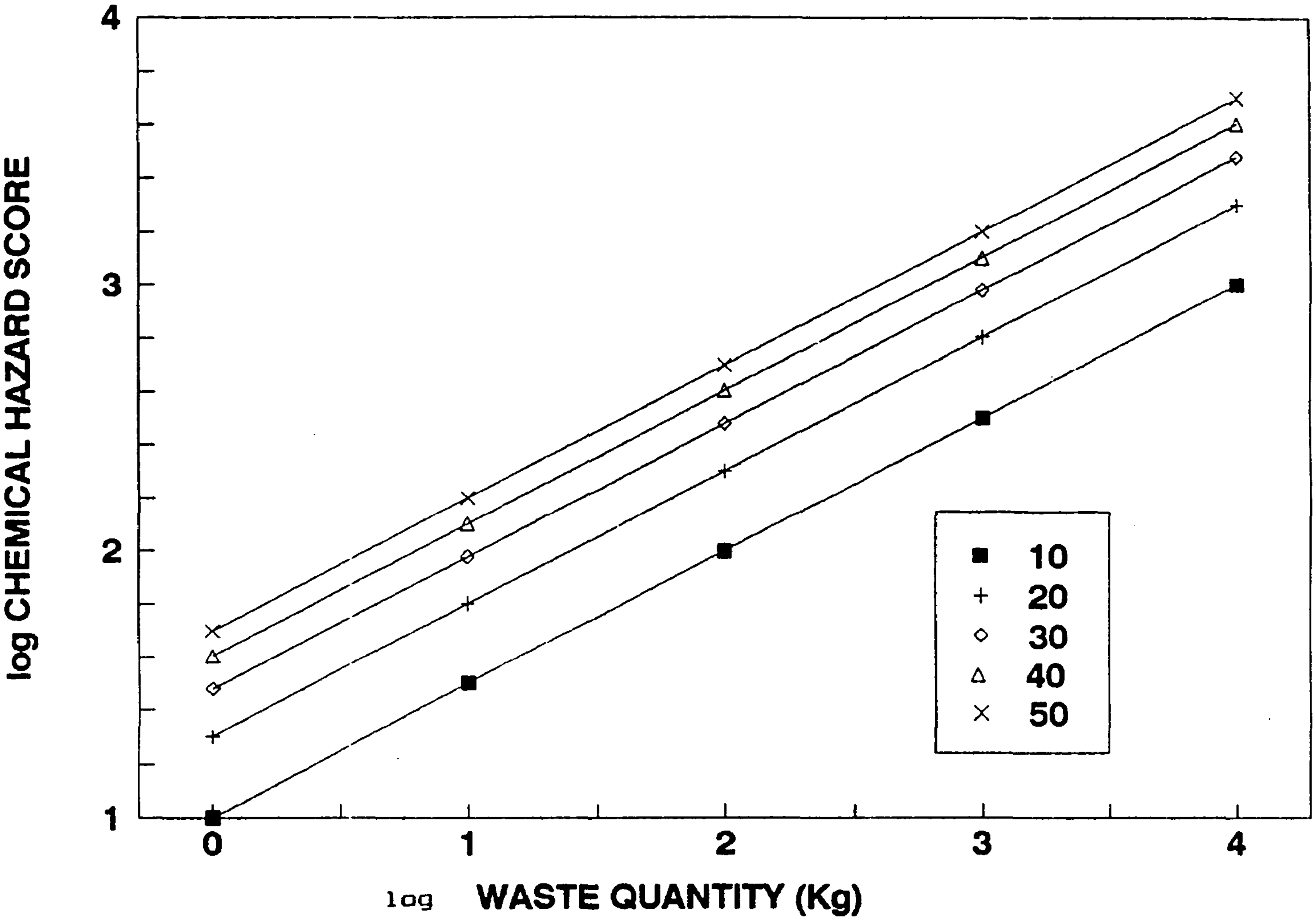


Figure 4.1 Relationship of Log Chemical Hazard Score to Log Waste Quantity for Selected Potential Toxicity Scores

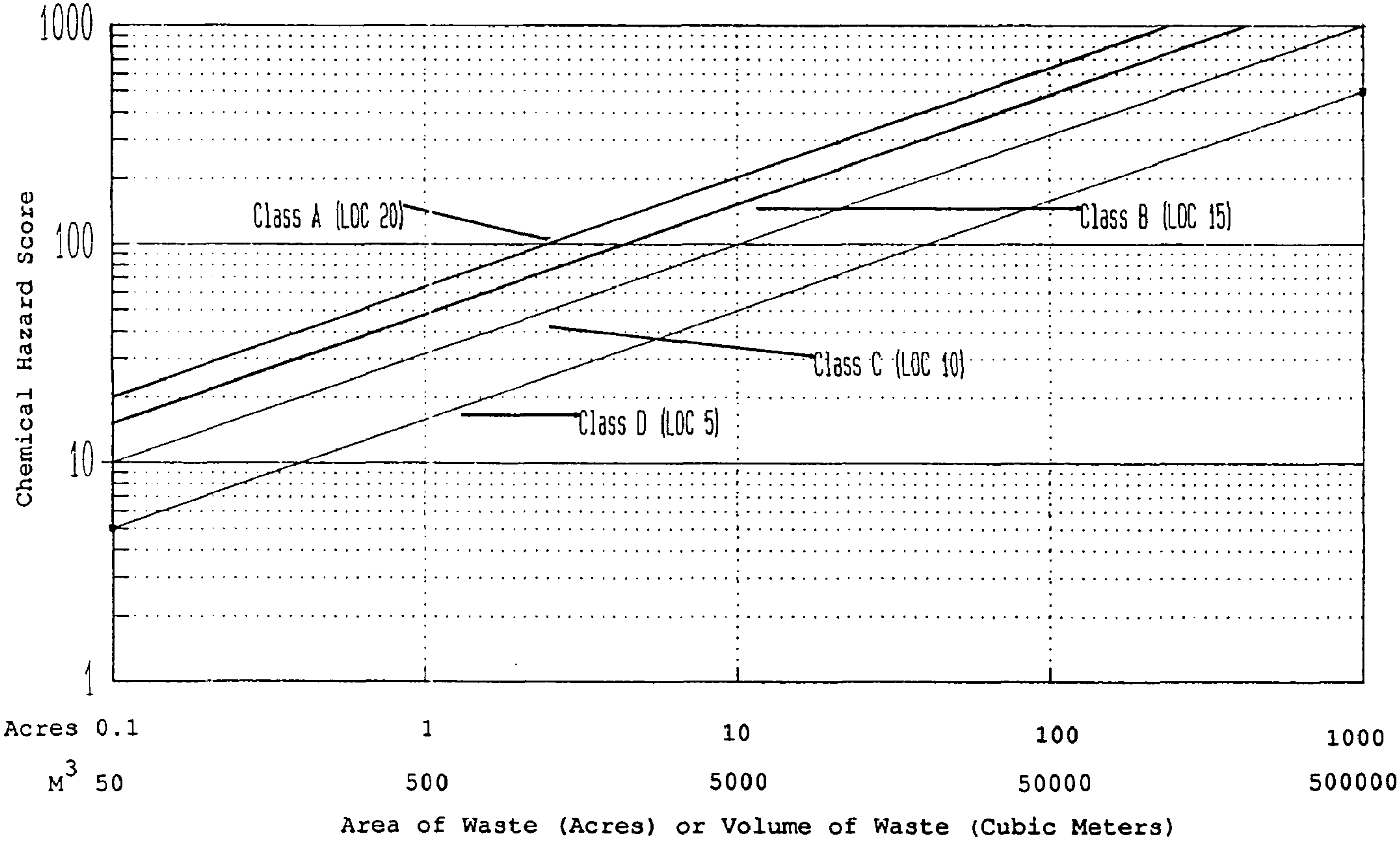


Figure 4.2 Relationship of Log Chemical Hazard Score to Log Waste Quantity (Acres or Volume of Waste) for the Waste Characterization Scoring Method

1.) Determine the identity and quantity (measured or estimated) of each unknown contaminant area via the general waste characterization system in Table 3.1. (Be sure that the amount of known contaminant waste is not included here by reducing the total amount of waste material on site by the amount of known contaminant).
2.) Select the designated potential toxicity factor for each characterized waste category and determine the chemical hazard score for that waste using the equation appropriate to the waste category. That is:

for waste Class A, use the equation

$$CH = PTF_{20}(Q^{0.5})$$

for waste class B, use the equation

$$CH = PTF_{15}(Q^{0.5})$$

for waste class C, use the equation

$$CH = PTF_{10}(Q^{0.5})$$

and for waste class D, use the equation

$$CH = PTF_{5}(Q^{0.5})$$

where CH is the waste category chemical hazard score, PTF is the potential toxicity factor designated for waste category A (20), B (15), C (10), and D (5), and Q is the quantity of characterized waste. The maximum score obtainable for each waste type is 1000 points while the maximum when more than one category is present is 1300 points. Record the score on Figure 3.1.

3.) To calculate the total waste characterization hazard score for the site, add the individual waste characterization hazard scores, the sum of which is the hazard score for those waste types on site. Record the total on Figure 3.1.

Total Chemical Hazard Category Score

The final total chemical hazard category score is calculated by adding the specific chemical waste hazard score to the waste characterization score. The maximum total chemical hazard score is 1300 points. Record this score on the Site Score Sheet, Figure 1.2.

5.0 Migration Potential

Migration potential considers those characteristics of the waste material and its containment which determine the likelihood that contaminants may be released to the environment and that they may migrate off-site. The Migration Potential is developed by calculating a Release Potential Factor and Environmental Fate Factor for each site. The Release Potential Factor depends upon the physical state of the contaminants on site and the condition of the containment structure or its ability to prevent contaminant release. The Environmental Fate Factor modifies the Release Potential Factor according to the predicted chemical behavior in the environment and the nature of the environment it has been released into.

5.1 Release Potential Factor

The Release Potential Factor considers site characteristics which influence the likelihood that wastes will be released to the environment and the rate at which the release may occur. The likelihood of release is determined by assessing the structural integrity of the containment structure while the rate of release is determined from the physical state of the waste at the time of its disposal.

1) If the source of contamination can be identified or if the identified contaminants are typical of the major constituents of gasoline or fuel oil, go to step 2. If the source of contamination cannot be identified (there is evidence of contamination such as a contaminated potable water well but no evidence of the point of release) go to step 3.

2) Calculate the Release Potential Factor for each containment structure on site using Figure 5.1.

- Identify all known containment structures known to exist at the site on Figure 5.1.
- For each containment structure, evaluate the adequacy of the applicable containment characteristics (cover, liner, or dike condition, freeboard or container condition) for each compartment of concern (ground water, surface water or air). In the upper left-hand corner of each compartment concern box, enter A, I, or U for adequate, inadequate or unknown. If all containment characteristics are defined as adequate, do not proceed further with scoring the containment structure.
- Determine the physical state of the material in each containment structure at the time of disposal and record the appropriate value from Table 5.1 in the physical state column (Column A) of Figure 5.1.
- Determine the quantity of material contained by each containment structure on site. These data are developed in Section 2.0 (Waste Quantification). If data for the various containment structures exist in different units (for example landfill data as acres and lagoon data as M^3), apply the common units estimation technique in the following Special Conditions subsection. Enter the waste quantity value for each

Containment Structure	Physical State Factor				EFF[f]	Release Potential G=EXF	Element	GW	SW	A
	Phys. State[a]	Q[b]	%[d]	Factor E=AXD						
Surface Impoundment	Base						Cover	☒		
							Liner		☒	☒
	Air						Dike	☒		☒
							Freeboard	☒		☒
Landfill	Base						Cover			
	Air						Liner		☒	☒
Containers	Base						Condition			
	Air							☒	☒	☒
Piles/Contaminated Soils	Base						Cover			
	Air						Liner		☒	☒
				TOTAL COMPARTMENT RELEASE POTENTIAL						

C. Total Quantity of Material on Site ____________________

Total Quantity of Air Compartment Materials on Site ____________________

Figure 5.1 Migration Potential Worksheet

Table 5.1 Release Potential Factors Based Upon the Physical State of the Waste at the Time of Disposal

Physical State	Score	
Solid	1.0	
Semi-solid	1.5	
Liquids and Gases	2.0	
Examples		
Landfill-demolition waste	1.0	
general waste	1.25	
industrial waste	1.5	unless liquids are known to have been disposed
organic chemicals	2.0	
Waste Piles	1.0	
Sludges	1.5	
Salt Storage Piles	1.0	
Surface Impoundment	2.0	
Gravel Pits	1.0/1.5/2.0	depending on waste
Drilling Mud Pits	1.5	
Holding Ponds	2.0	
Containers	1.0/1.5/2.0	depending on waste
Wells (dry, oil, injection)	2.0	
Spray Irrigation	2.0	
Fertilizer Application	1.0/2.0	depending on form
Road Brining	2.0	
Spills	1.0/1.5/2.0	depending on waste
Septic Tanks	2.0	if receiving non-sanitary waste

containment structure in Column B on Figure 5.1 (using common units).

- If applicable, enter a separate waste quantity value for consideration in connection with a potential air release from the site. Use Table 5.2 and its footnotes from the following Special Conditions subsection or calculate a quantity using the top 6 inches of soil and the surface area of a landfill. The entire volume of a lagoon is used to calculate release potential of volatile substances to the air.
- Estimate the total quantity of material on site and enter at C on Figure 5.1.
- Estimate the total quantity of Air Compartment materials on site and enter at F on Figure 5.1.
- Calculate the percent of material contained by each structure by dividing B by C. Enter the value for each containment structure at D on Figure 5.1. For the Air Compartment materials, divide the air quantity in B by the total quantity of air materials at F and enter at D.
- Calculate the Release Potential Factor for each containment structure by multiplying A times D. Enter at E. If applicable, calculate the air value in the same manner.

3) If surface water, ground water, or air contamination is known but the source of the contamination is not known, there is insufficient information to complete scoring step 2. Because contamination already exists, a release from a containment structure has already occurred. Therefore, apply a release potential of 2.0 only to those compartments known to be contaminated.

Special Conditions

Common Units Conversion

This method is applied only to obtain common units for developing Release Potential. Waste quantification for Chemical Hazard scoring is done in Section 3.1. There are a variety of methods available to estimate contaminant quantities.

- When a reliable estimate of the number of barrels, size of lagoons or area of contaminated soils is known, but concentration data are not known, waste quantity estimations may be made from Table 5.2.
- When concentration data are known, kg values must be adjusted according to the guidance provided in Section 3.0.
- When the volume of a waste area is known, i.e. surface area and depth of a fill area, lagoon or sludge pit, kg for a waste type characterization may be estimated assuming 2000 kg/m^3 for a solid, 1500 kg/m^3 for a sludge and 1000 kg/m^3 for a liquid. For contaminated soils, assume a density of 1500 kg/m^3 for saturated soils and 500 kg/m^3 for non-saturated soils.
- If the waste type has been characterized (Section 3.0) and the depth of a landfill is known but kg values are needed to compare to other containment structures, assume a density of 2000 kg/m^3 for a class A waste, 1500 kg/m^3 for a class B waste,

Table 5.2 Hazardous Waste Quantity Conversion Factors

Kg[1]	55 Gallon Drums	Tons	Lagoons Cubic Yards	Solids Soils [2] Landfill	Landfill Air [3] Material
$5x10^{3}$	1-20	<5	1-16	<3 acres	100
$1.5x10^{4}$	21-100	5-25	17-160	3-5	300
$7.5x10^{4}$	101-500	26-125	161-880	6-20	1500
$1.9x10^{5}$	501-1000	126-250	881-1600	20-30	3800
$5x10^{5}$	1001-3000	251-750	1601-6400	30-40	10000
$1x10^{6}$	3001-5000	751-1250	6401-11200	40-50	20000
$1.3x10^{6}$·	>5000	>1250	11201-26000[3]	>50	26000[4]

[1] When calculating kg assume the following densities:
- -2000kg/m^3 for a solid
- -1500 kg/m^3 for a sludge
- -1000 kg/m^3 for a liquid
- -Calculate air compartment materials using the top six inches of area and convert to kg
- -If materials in a lagoon or barrel have solidified, calculate cubic feet of solid material and convert to kg. Air compartment materials, calculate the surface area instead of total kg

[2] Soils and solids only - for liquids use entire volume of liquid. For any containment structure larger than those on chart, calculate air compartment materials

[3] If a landfill is greater than 50 feet in depth or 100 acres in area or if a lagoon is greater than 26000 cubic yards, calculate actual kg and do not use above chart

[4] For landfills 50-100 acres

1000 kg/m^3 for a class C waste and 500 kg/m^3 for a class D waste.

- If the actual area of a site is not known (for example a landfill area) use one-half the size of the property area as the landfilled portion unless a reasonable estimate of the proportion of the affected property can be made.
- If only the area of contaminated soils is known or reasonably estimated, assume contamination extends to a depth of three feet.
- For 55 gallon drums, assume a mass of 200 kg per drum for a liquid, 250 kg for a sludge and 300 kg for a solid. If the percent composition of the drum contents is known from labels or other records, calculate the pure quantity of contaminent.
- The air compartment quantities are estimated from Figure 5.2 or are based on the top six inches of contaminated soil. If the contaminants or their containment structures are buried under at least 6 feet of overlying uncontaminated soil, it is assumed that the materials are not likely to be released to the atmosphere and the air compartment materials are not added to the waste quantity figure.

Apply the "O'Dell's Gas City" method if unknown amounts of gasoline or fuel oil are lost or spilled. Assume a 300 gallon loss if small volume losses have resulted from spills, accidents, small tank leaks (500 gallon capacity or less) or truck to tank transfers have occurred, or if contamination has been detected and a possible or likely source of contamination has been identified within 1/2 mile of the contamination site. Assume a 3000 gallon loss if there is a known release from a large capacity tank (either above or under ground of a volume greater than 500 gallons) but inventory records are unavailable or do not quantify actual losses. If contamination has been detected but no known likely or possible source has been identified within 1/2 mile of the site, assume 3000 gallons. In order to apply O'Dell's method when contamination has been detected, certain major constituents of gasoline (benzene, toluene, ethylbenzene and xylene) must be identified in the samples. If the quantity of gasoline or fuel oil lost is known, modify the constituent scoring sheets to account for the known quantity.

If there has been a known release from a containment structure, it is obvious that the containment structure has failed and the Release Potential Factor for that structure should be 2.0, not the release potential appropriate to the physical state of the contaminant at the time of its disposal.

If contamination extends beyond the site ownership boundaries, consider the entire contaminated area as the site.

5.2 Environmental Fate Factor

The Environmental Fate Factor is used as a modifier to the Release Potential Factor to evaluate the probability that a contaminant, once it has escaped its containment, will reach an environmental resource.

The general mechanism is to derive a Physical Parameter Index which is integrated with a chemical specific parameter to obtain the Environmental Fate Factor for each resource compartment. The Physical Parameter Index describes the impeding medium while the chemical parameter is some property which affects contaminant mobility. When the specific contaminants are unknown and the site is defined in general terms by waste characterization, the chemical parameter has to be derived in general terms as well. This is done in Section 5.2.4.

The Physical Parameter Index is developed by multiplying the medium type index by the extent index according to the formula:

$$PPI=MTI*EI$$

Where PPI is the Physical Parameter Index, MTI is the medium type index and EI is the extent index.

The Environmental Fate Factor is derived by entering a table with the Physical Parameter Index and the contaminant parameter.

5.2.1 Ground Water Compartment

In the Ground Water Compartment, the Physical Parameter Index depends upon the characteristics of the soils of the overburden, which impede water and contaminant flow, and the thickness of the zone in question. The Index is derived by multiplying the Medium Type Index (Table 5.3) by the Medium Thickness Index (Table 5.4). The values obtained from these tables are recorded in their respective columns of Figure 5.2.

For those overlying soils which consist of more than one layer, the medium type index should be derived using a weighting technique. The medium index for each layer should be multiplied by the thickness of the layer, all layer indices added together and then divided by the total thickness of the overlying soils. This weights the index toward the dominant layer(s).

Organic Contaminants

For organic contaminants, water solubility and adsorptivity by the environment operate as independent characteristics. These can be predicted using a single chemical parameter, the octanol/water partition coefficient (log Kow) Table 2.5. If more than one organic contaminant is present, derive a weighted log Kow by multiplying the log Kow for each contaminant by the quantity of contaminant present, adding these values, and dividing the sum by the total quantity of waste present. Record this value on Figure 5.2.

The Environmental Fate Factor is obtained from Table 5.5 using the PPI and the weighted log Kow from the worksheet (Figure 5.2.) Record the Environmental Fate Factor on Figure 5.2.

Table 5.3 Ground Water Compartment Medium Type Index for Development of the Physical Parameter Index

Medium	Index
gravel	10
sand	9
loam/peat	6
silt	4
clay	2

Table 5.4 Ground Water Compartment Medium Thickness Index for Development of the Physical Parameter Index

Thickness	Index
<1m	10
1-5m	8
5-10m	6
10-20m	4
>20m	2

GROUND WATER

Medium Type Index	Thickness Index	Physical Parameter Index

Containment Structure	Contaminant	Release Potential	Quantity	Log Kow	EFF	RPF
Weighted Averages						

SURFACE WATER

Medium Type Index	Slope Index	Physical Parameter Index

Containment Structure	Contaminant	Release Potential	Quantity	Water Solubility	EFF	RPF
Weighted Averages						

AIR

Medium Type Index = Physical Parameter Index

Containment Structure	Contaminant	Release Potential	Quantity	Vapor Pressure	EFF	RPF
Weighted Averages						

EFF = Environmental Fate Factor
RPF = Release Potential Factor

Figure 5.2 Release Potential and Environmental Fate Factor Worksheet

Table 5.5 Ground Water Compartment Organic Contaminant Environmental Fate Factor Derived from the Physical Parameter Index and Contaminant Log Kow

	Organic Contaminant Log Kow			
PPI	<1.5	1.5-3.0	3.0-4.5	>4.5
76-100	2.0	1.5	1.25	1.0
51-75	1.5	1.25	1.0	0.8
26-50	1.25	1.0	0.8	0.6
4-25	1.0	0.8	0.6	0.4

Inorganic Contaminants

Inorganic contaminant mobility is predicted by setting up very general, broad mobility scales (mobile, moderately mobile and immobile) in Table 5.6 for each inorganic contaminant over a range of pH values. When scoring a site, it will be necessary to obtain or make a reasonable estimate of site soil and contaminant pH. If more than one inorganic contaminant is present at the site, a weighted average mobility factor must be derived. This is done by obtaining a mobility factor for each contaminant, assigning a value of 0 to immobile contaminants, 1 to moderately mobile contaminants, and a value of 2 to mobile contaminants, multiplying the values for each contaminant by its quantity, adding the resulting values, and dividing by the total quantity of inorganic contaminants present. Record this weighted value on Figure 5.2.

The Environmental Fate Factor is developed in Table 5.7 by calculating the PPI and finding the appropriate column which corresponds to the weighted metal mobility derived from Table 5.6. Record the factor on Figure 5.2.

5.2.2 Surface Water Compartment

In the Surface Water Compartment, the Environmental Fate Factor depends on physical parameters related to soil infiltration versus overland runoff and water solubility of the contaminant. Soil infiltration is related to the permeability of the surface soils which loosely corresponds to soil type. The probability of overland runoff correlates with site slope.

The Physical Parameter Index is derived by multiplying the Medium Type Index (Table 5.8) by the Slope Index (Table 5.9). Enter the Physical Parameter Index on Figure 5.2.

Organic Contaminants

Water solubility is the only chemical specific parameter applied to the Surface Water Compartment Environmental Fate Factor. Obtain the water solubility of each site contaminant from Appendix A. If more than one organic contaminant is present, derive a weighted water solubility value by multiplying the water solubility for each contaminant by the quantity of contaminant present, adding these values, and dividing the sum by the total quantity of waste present. Record this value on Figure 5.2.

The Environmental Fate factor is obtained from Table 5.10 using the PPI and the weighted water solubility value from the worksheet (Figure 5.2). Record the Environmental Fate Factor on Figure 5.2.

Inorganic Contaminants

Inorganic contaminant water solubility in overland flow is predicted by a single scale at pH 5.0 (Table 5.11). If there is more than one inorganic contaminant present, apply the same weighting process

Table 5.6 Ground Water Compartment Inorganic Contaminant Mobility

pH	Al	As	B	CN	Cd	Cu	Cr	Hg	Ni	Pb	Zn
4	M	M	M	I	M	M	M	M	M	MM	M
5	M	M	M	I	M	M	M	M	M	MM	M
6	M	M	M	I	MM	M	MM	MM	MM	MM	M
7	MM	M	M	I	MM	M	I	MM	MM	I	M
8	I	MM	MM	I	I	M	I	I	MM	I	MM
9	I	I	MM	I	I	M	I	I	I	I	MM

M = mobile, MM = moderately mobile, I = immobile

Table 5.7 Ground Water Compartment Inorganic Contaminant Environmental Fate Factor

PPI	Mobile	Moderately Mobile	Immobile
76-100	2.0	1.5	1.0
51-75	1.5	1.0	0.8
26-50	1.0	0.8	0.6
1-25	0.8	0.6	0.4

Table 5.8 Surface Water Compartment Medium Type Index for Development of the Physical Parameter Index

Medium	Index
gravel	2
sand	4
loam/peat	6
silt	8
clay	10

Table 5.9 Surface Water Compartment Slope Index for Development of the Physical Parameter Index

Slope	Index
all surrounding terrain higher	0
< 3%	2
3-5%	4
5-8%	6
> 8%	8

Table 5.10 Surface Water Compartment Organic Contaminant Environmental Fate Factor Derived from the Physical Parameter Index and Contaminant Water Solubility

	Water Solubility (ppb)			
PPI	<1	1-1.5E+1	1.6-1E+3	>1E+3
4-20	0.4	0.6	0.8	1.0
21-40	0.6	0.8	1.0	1.25
41-60	0.8	1.0	1.25	1.5
61-80	1.0	1.25	1.5	2.0

Table 5.11 Inorganic Contaminant Mobility in Surface Water

		Inorganic Compound						
	As	CN	Cd	Cu	Cr	Ni	Pb	Zn
Mobility Factor	M	I	M	M	MM	M	MM	M

I = Immobile
MM = Moderately Mobile
M = Mobile

described for the organic contaminants in the ground water subsection (Section 5.2.1).

The Environmental Fate Factor for inorganic contaminants is derived from Table 5.12 using the Physical Parameter Index and the weighted mobility factor recorded on the worksheet (Figure 5.2).

5.2.3 Air Compartment

In the Air Compartment, the environmental fate factor is used to indicate the inherent potential for chemicals present at a site to be released to the ambient air. It is derived from the type of soil overlying a containment structure and the vapor pressure of the materials present in the structure.

The Physical Parameter Index depends upon whether there are exposed liquids in lagoons or open barrels, or the pore space of contaminated soils or soils covering containment structures. The Physical Parameter Index is developed in Table 5.13 for exposed liquids and various soils. Record the Physical Parameter Index on Figure 5.2.

Organic Contaminants

Volatility of organic contaminants is predicted by the vapor pressure of the contaminant. Obtain the vapor pressure value for the site contaminant from Table 2.5 and record on Figure 5.2. If more than one organic contaminant is present, derive a weighted vapor pressure value by multiplying the vapor pressure value for each contaminant by the quantity of contaminant present, adding these values, and dividing the sum by the total quantity of waste present. Record this value on Figure 5.2.

The Environmental Fate factor is obtained from Table 5.14 using the PPI and the weighted vapor pressure value from the worksheet (Figure 5.2). Record the Environmental Fate Factor on Figure 5.2.

Inorganic Contaminants

There is no need to develop a separate Environmental Fate Factor for inorganic compounds because few of them are considered volatile. Volatility of inorganics can be considered using the same matrix developed for organic compounds because, for those compounds (for example, mercury and HCN) which can be considered volatile, vapor pressure values are available.

5.2.4 Environmental Fate Factor By Waste Characterization

If the specific contaminants at an environmental contamination site are unknown, the Environmental Fate Factor is derived via a waste type method.

The Physical Parameter Index derived in Subsection 5.2.1 for ground water, 5.2.2 for surface water, and 5.2.3 for air are used for the waste type method.

Table 5.12 Surface Water Compartment Inorganic Contaminant Environmental Fate Factor derived from the Physical Parameter Index and Contaminant Mobility

	Mobility Factor		
PPI	Immobile	Moderately Mobile	Mobile
4-20	0.6	0.8	1.0
21-40	0.8	1.0	1.25
41-60	1.0	1.25	1.5
61-80	1.25	1.5	2.0

Table 5.13 Air Compartment Physical Parameter Index

Medium	Index
lagoon/open barrel	10
gravel	10
sand	9
loam/peat	6
silt	4
clay	2

Table 5.14 Air Compartment Environmental Fate Factor

	Vapor Pressure (mm. Hg @ 20 deg.C)			
PPI	<=0.002	>0.002-<=0.1	>0.1-<=1.0	>1.0
2	0.25	0.50	0.75	1.00
4	0.50	0.75	1.00	1.25
6	0.75	1.00	1.25	1.50
8	1.00	1.25	1.50	1.75
10	1.25	1.50	1.75	2.00

The waste type characterization method of chemical hazard scoring identifies five hazard groups (Table 3.1) by waste type based on a grouping of the sources. The mobility classifications applied to each waste type category for each of the environmental media are shown in Table 5.15.

Once the mobility has been characterized for the waste categories, the Environmental Fate Factor is derived from Table 5.16. The table is entered using the Physical Parameter Index appropriate to the medium being evaluated and the mobility characterization from Table 5.15. Note that if a Physical Parameter Index of 2 is derived for the air medium, an Environmental Fate Factor of 0.25 is used.

5.3 Final Completion of Compartment Release Potential

Averaging the Environmental Fate Factor

When more than one contaminant is present at a site, it is necessary to average the contaminant specific Environmental Fate Factors (EFF) to derive a factor representative of the site. If the quantity of each contaminant is known, multiply each EFF by its quantity, add these values for all contaminants and then divide by the total quantity of waste on site. This will weight the factor toward the dominant contaminant(s). If the quantity of each contaminant is not known or are in different units, the EFF may be weighted according to the common units developed in Special Conditions of subsection 5.1 and recorded in Figure 5.1.

Calculate the Compartment Migration Potential for each containment structure by multiplying the Release Potential Factor (column E) times the Environmental Fate Factor (column F). Note that there are two Release Potential Factors (due to the lesser quantity of Air Compartment materials relative to the total quantity of material on site) but only one Environmental Fate Factor for each containment structure. This requires calculation of two Compartment Migration Potential values.

For each containment structure characteristic declared Inadequate or Unknown, enter the specific Compartment Migration Potential value from Column G into each compartment of concern box. Note that a separate Compartment Migration Potential value was calculated in column E and that there is a separate value in column G for the Air Compartment.

4) Develop the Total Compartment Migration Potential value for each Compartment of Concern by adding the migration potential values for each environmental compartment for all affected containment structures. Add only among containment structures, not within (for example, if both the cover and liner for a landfill have been declared inadequate and the Migration Potential Factor is 1.5, the Migration Potential Factor for the landfill is 1.5 not 3.0). Record each compartment Migration Potential value on Figure 1.2.

Table 5.15 Waste Characterization Contaminant Mobility According to Environmental Medium

Environmental Medium	Waste Type Category A	B	C	D	E
Ground Water	MM	MM	M	M	I
Surface Water	MM	M	M	M	I
Air	M	MM	M	MM	I

I = Immobile
MM = Moderately Mobile
M = Mobile

Table 5.16 Waste Characterization Environmental Fate Factor

Physical Parameter Index GW	SW	Air	Mobility Parameter Mobile	Moderately Mobile	Immobile
76-100	61-80	10	2.0	1.5	1.0
51-75	41-60	8	1.75	1.25	0.75
26-50	21-40	6	1.5	1.0	0.5
4-25	4-20	4	1.25	0.75	0.25

6.0 Population At Risk

The Population at Risk subcategory assesses the potential size of the human population that may be affected by an environmental contamination site if a release from that site were to occur. Note that if the Migration Potential score is zero for any of the environmental compartments, the Population at Risk for that compartment should not be estimated.

Scoring Procedure

1) Draw a one-half mile radius on a topographic map to define the target area. If the site is large or irregular in shape, draw the target area as one-half mile from the site boundaries where the boundaries are the furthest known extent of contamination. This includes the extent of a migrated plume, either ground or surface water, or contaminants deposited by air transport when the contaminants are known or strongly suspected to have originated from the primary site.

2) Count the number of homes within the target area. If in a metropolitan area, apportion the most recent population census data according to the proportion of the target area within the incorporated area.

- For the ground water compartment, determine the direction of ground water flow if possible. If the direction of flow is known from on-site wells or direct measurement, strike a one - half mile radius 90 degree arc centered on the direction of groundwater flow and count the number of homes within the arc. If the direction of ground water flow is not known from on-site measurements but may be inferred from land topography or the presence of a lake or stream within the one-half mile radius, strike a 180 degree arc centered on the direction of inferred ground water flow and count the number of homes within the arc. If the direction of ground water flow is not known and cannot be reasonably inferred, count all homes within the one-half mile radius. If there is a discontinuity (such as a perennial stream or lake) which may impede or alter the ground water flow, truncate the radius at the discontinuity and do not include homes beyond the discontinuity in the home count. Similarly, if there is a large capacity well or other geological feature which may extend the ground water flow beyond the limits of an arc, include that flow direction within the arc. Include only those homes using ground water for drinking water: if some or all of the homes are supplied by a public drinking water system, do not include these homes in the counts unless the source well is within the one-half radius. If it is unknown whether homes in the area rely on ground water for their potable water, include them in the counts. Record the number of homes in the Ground Water Compartment column of Figure 6.1.

Ground Water and Air Compartments		
	GW	AIR
Number of Homes		
Number of People		
Drinking Water Supply		
Total Number of People		
Points from Table 6.1		
Additional Points (max. 15)		
Hospital		
School		
Nursing Home		
TOTAL POINTS		

Surface Water Compartment		
	Number of People	Points From Tables 6.1-3
Drinking Water Population		
Bathing Population		
Bathing Beach		
Public Access		
shoreline		
Fish Consumption		
Shoreline		
Public Access		
Additional Points (max 15)		
Hospital		
School		
Nursing Home		
TOTAL POINTS		

Figure 6.1 Population at Risk Worksheet

- For the Air Compartment, count all homes within the one-half mile radius and record in the Air Compartment column of Figure 6.1.

- Multiply the number of homes in each compartment column by four to obtain the potentially affected population. For metropolitan areas (areas shaded in pink on the topographic maps) the most current census population data should be used. If the entire one-half mile radius is within the metropolitan area, calculate the population by multiplying the census datum by 0.78 (to convert the one-half mile radius area to square miles, the numerical base of the census) and then multiplying the result by the fraction that the target area makes up of the metropolitan area. If any of the target area is not within the shaded area, estimate the number of additional homes according to the procedure in part 2) above. Enter the resulting population in Figure 6.1.

- For additional drinking water population, determine whether there are any surface water intakes or municipal wells within the one-half mile radius of the site (including the 5 mile stream and one-half mile lake extensions) which are used by public water supply systems as a source of potable water. Include the entire population supplied by the public water supply system in the appropriate ground water or surface water drinking water supply row.

- Estimate the surface water bathing or fish ingestion populations at risk five miles downstream in a flowing water body and one-half mile radius along a lake shore in both directions from the potential lake entry point, according to the following access groups.

    - For body contact attributable to bathing beaches, determine the capacity of the beach parking area (number of parking slots or estimated number of cars which can park in the designated area-available from the Parks Division) and multiply by an assumed value of four people per car.
    - For body contact attributable to public access sites, determine the capacity of the access parking area (number of parking slots or estimated number of cars which can park in the designated area-available from the Waterways Division or District Fisheries Division Office) and multiply by an assumed value of two people per car.
    - For body contact attributable to shoreline access, apply the actual population densities, if known. If actual densities are not known, count the number of homes on a topographic map within the zone of influence and assume a population of four people per home. Alternatively, the affected population may be estimated from a direct count of the number of homes within the affected area. A direct count of the number of homes (seasonal or year-round) may be obtained either from site vicinity survey or MDNR

aerial photographs (available in the Land and Water Management Division).

-For metropolitan areas, apportion the regional population from the most recent census according to the area affected (see guidance above).

-For the five mile extension areas, include those homes within 1/2 mile of the included shoreline.

-For fish ingestion risk, apply the population estimates described above for public access sites and shoreline population.

3) From Table 6.1, determine the number of points to be assigned to the Air Compartment for the population at risk and the Ground Water and Surface Water Compartment drinking water populations at risk. Enter the points for each compartment (column) in the population points row. From Table 6.2, determine the number of points to be assigned to the Surface Water Compartment for body contact risk. From Table 6.3, determine the number of points to be assigned to the Surface Water Compartment for fish ingestion risk. Enter the points on Figure 5.1.

4) Determine whether hospitals, nursing homes or schools are located within the one-half mile radius of the site and enter five points for each institution type in the additional targets row for each compartment. Note: even if there are more than one of a type of institution within the target area, (for example, two schools) only five points are entered for the institution type. Enter the appropriate points on Figure 6.1.

5) Add the total points for each compartment (column) and enter the result in the total points row for each compartment for Figure 6.1 and transfer to Figure 1.2.

Table 6.1 Point Values for Drinking Water and Air Population at Risk

Population at Risk	Points
0	0
1-12	20
13-24	30
25-100	40
101-250	50
251-500	60
501-750	70
751-1000	80
1001-3000	90
3001-10000	95
>10000	100

Table 6.2 Bathing Population at Risk

Population Estimate	Points
Beach or Shoreline	
unimproved, <10 cars, 0-40 people	10
small, 11-25 cars, 41-100 people	20
moderate, 26-75 cars, 101-300 people	30
large, >75 cars, >300 people	40
Public Access	
<15 cars	5
>15 cars	10

Table 6.3 Fish Ingestion Risk

Population Estimate	Points
Shoreline Population	
<50 homes, 200 people	20
51-100 homes, 204-400 people	40
>100 homes, >400 people	60
Public Access	
<15 cars	20
>15 cars	40

7.0 Groundwater Compartment Completion

7.1 Existing Exposure

The Existing Exposure Category assesses the extent to which people or the environment in the vicinity of a contamination site have been exposed to a known release from the site. Existing Exposure is scored only when ground water contamination is documented by direct chemical analysis. This equates to a determination that there has been a known release from the containment structure(s) at the site which has resulted in some level of contamination.

Scoring Procedure

Identify each contaminant and its concentration on Figure 7.1. If the contaminant has been detected at more than one sampling location or in more than one sample from a sampling location, record the greatest concentration detected.

Subtract the background level from the contaminant concentration to derive the exposure concentration for each contaminant. Using Table 7.1, select the appropriate Chemical Exposure Factor and enter on Figure 7.1. Using Table 7.2, select the appropriate Environmental Exposure Factor (either a monitoring well value or irrigation/ livestock values plus human population values) and enter on Figure 7.1. Multiply the Chemical Exposure Factor by the Environmental Exposure Factor for each chemical and record under score on Figure 7.1. Total the individual chemical scores to derive the Existing Exposure Score.

Special Conditions

Note that the total Existing Exposure Score is not to exceed 300 points if both irrigation/livestock wells and human drinking water wells are impacted. If human drinking water wells are exclusively impacted, the maximum score is 250 points. If only monitoring well contamination is known at the site, note that the maximum Existing Exposure Score is either 75 points if a surficial or water table aquifer is impacted or 125 points if an artesian or protected aquifer is impacted.

There is a distinction between water table and artesian aquifers when considering contaminated monitoring wells. A water table aquifer is meant to include near surface, unprotected aquifers. It may also include perched, unprotected water lenses. An artesian aquifer is intended to include protected useable aquifers. The key requirement is that the aquifer is protected by an impervious layer (such as clay or shale). If a contaminated monitoring well is completed in a water table aquifer and nearby (within one-half mile of the contamination site) private potable water supply wells are known to be completed in the same aquifer, apply the base artesian aquifer value of 12.5 instead of 7.5 for the water table aquifer.

When estimating the human population served by contaminated water supply wells, use known household specific populations if available.

Chemical	DEL	BL	DEL - BL	CEF	PE	PF	Score
						TOTAL	

DEL	Documented Exposure Level
BL	Background Level
CEF	Chemical Exposure Factor
PE	Population Exposed
PF	Population Factor

Figure 7.1 Ground Water Compartment Existing Exposure Worksheet

Table 7.1 Ground Water and Surface Water Compartments Chemical Concentration Exposure Factor

Concentration Above Background Levels (ppb)	Chemical Exposure Factor
<10	2
10 - 50	4
51 - 500	6
501 - 1000	8
>1000	10

Table 7.2 Ground Water Compartment Environmental Exposure Factor

Parameter	Factor
Monitoring Well	
Water Table Impact	7.5
Artesian Aquifer Impact	12.5
<u>OR</u>	
Livestock/Irrigation Well	5
<u>PLUS</u>	
Drinking Water Well(s)	
Population Served	
1 - 24	15
25 - 100	18
101 - 1000	20
1001 - 10,000	22
>10,000	25

In cases where only the number of households serviced by private wells or a central well is known, estimate the population assuming that the average household consists of four people. If a public water supply system is contaminated and the direct population served is not known, determine the municipal area served by the system and apportion the population of the municipality from the most current national census population data according to the area served. If separate seasonal populations are known, divide that population by two on the assumption that it is not exposed on a year-round basis. If an industrial or commercial establishment has a contaminated well, apply the number of employees if known. Do not apply population estimates for customers. If an apartment building or other multiple family dwelling is served by a contaminated well, obtain the resident population or number of units in the dwelling and assume a unit population of three people.

When determining contaminant concentration, use the greatest confirmed concentration detected from all samples collected within the preceding 12 months. Background data or state-wide average background values are to be subtracted from the representative values where applicable.

If a permanent, uncontaminated water supply system has been installed and the contaminated system has been taken off-line or plugged, do not include the population served by the new system in the population estimates. The aquifer which served the abandoned well is still considered contaminated and should be scored using the monitoring well approach.

7.2 Potential Exposure

The Potential Exposure Category assesses the probability that a discarded hazardous substance may be released from its containment in a quantity which is or may become injurious to the environment or to the public health, safety or welfare.

Scoring Procedure

The scoring criteria for the Ground Water Compartment assess the relative ability of the subsurface geological material to minimize or prevent a contaminant from migrating to a useable aquifer. The data should be derived from a minimum of three area water well records or site specific boring logs.

The useable aquifer is defined as a water bearing geological formation which is capable of providing a potable water supply and extends below a depth of 25 feet. This is to be evaluated on a regional aquifer use basis. Depth to the useable aquifer (or the thickness of the overlying soils) is measured vertically from the lowest point of contaminant containment to the highest point of the useable aquifer, including the containment layer above the useable aquifer (usually clay) if one exists.

I. Identification of Useable Aquifer
  A. Determine what aquifers are being used by residents within the 1/2 mile radius surrounding the site. Use water well records, conversations with local health officials, or home owners. Define the first aquifer at depth of 25 feet or greater as the useable aquifer.
  B. Determine whether there are individuals who use wells (constructed prior to February 14, 1967) within the one-half mile radius which exist to a depth less than 25 feet. If there are, define that aquifer as the useable aquifer.
  C. Record the earth materials and thickness intervals of all overlying soils between the useable aquifer and the containment structure on Figure 7.2. Define the earth materials according to the criteria in Figure 7.3.
  D. Record the depth intervals and earth materials of all aquifers and intervening non-aquifer materials on Figure 7.2. Define the earth materials according to the criteria in Figure 7.4.

II. Score Overlying Soil Materials
  A. Determine the earth material score for each overlying soil interval from Figure 7.4 using the thickness and earth material classification from Figure 7.2.
  B. Determine the weighted average for each interval and multiply by each score derived in III. A. above.
  C. Add the weighted scores to derive the total score for the overlying soils and record on the site score sheet, Figure 1.2.

7.3 Targets

Targets are defined as the environmental and human resources within a one-half mile radius of the contamination site which may be impacted by a release. In the Ground Water Compartment, Targets are evaluated as Population At Risk for the human resources and as the useable aquifer for the environmental resources.

Scoring Procedure

Score Useable Aquifer Materials
  A. Determine the earth material score for each interval from Figure 7.3 using the thickness and earth material classification from Figure 7.2.
  B. Determine the weighted average for each interval and multiply by each score derived in II. A. above.
  C. Add the weighted scores to derive the total score for the useable aquifer and record on the site score sheet, Figure 1.2.

Well Number______ Distance from Site______ Well Depth______

OVERLYING SOILS Total Layer Thickness_______

Unit Lithology	Unit Thickness	Layer Score	Percent of Total Layer	Weight Value
		Total		

USEABLE AQUIFER Total Layer Thickness_______

Unit Lithology	Unit Thickness	Layer Score	Percent of Total Layer	Weighted Value
		Total		

Lithology/Earth Materials Descriptors with Codes:
Gravel (G)
Coarse Sand (CS)
Medium Sand (MS)
Fine Sand (FS)
Very Fine Sand (VFS)
Sand with <15% Clay, Silt (SCS)
Sand with >15% but <50% Clay (SC)
Clay with <50% Sand or Gravel (CSG)
Clay (C)
Cavernous or Fractured Limestone (FL)
Evaporites (E)
Basalt Lava Fault Zone (BFZ)
Fractured Igneous Metamorphic Sandstone (FMS)
Moderately Cemented Sandstone (MCS)
Well Cemented Sandstone (WCS)
Fractured Shale (FS)
Siltstone (SS)
Unfractured Shale (USH)
Igneous and Metamorphic Rock (IMR)

Figure 7.2 Representative Well Record

EARTH MATERIAL CATEGORY				
Glacial Deposits	Gravel Sand & Gravel	Fine to very Fine Sand	Sand with <15% Clay	Clay with <50% Sand
Consolidated Rock	Cavernous or Fractured Sedimentary Rock, Fault Zones, Basalt Lava	Fractured Igneous or Metamorphic Rock, Poorly Cemented Sandstone	Moderately to Well Cemented Sandstone, Fractured Shale	Siltstone, Unfractured Shale, or other Impervious Rock
Representative (cm/sec) Permeability (gpd/ft^2)	>10E-2 >200	10E-2 to 10E-4 200 to 2	10E-4 to 10E-6 2 to 0.02	<10E-6 <0.02

RATING MATRIX

	>100	100	60	40	20
USEABLE	50-100	80	50	30	15
AQUIFER	10-50	60	40	20	10
THICKNESS	3-10	40	30	10	5
(feet)	<3	20	10	5	1

Figure 7.3 Useable Aquifer Scoring Matrix

EARTH MATERIAL CATEGORY	I	II	III	IV	V	VI
Glacial Deposits	Gravel, Medium to Coarse Sand	Fine to very Fine Sand	Sand with <15% Clay &/or Silt	Sand with >15% but <50% Clay &/or Silt	Clay or Silt with <50% Sand	Clay
Consolidated Rock	Cavernous or Fractured Limestone, Evaporites, Basalt Lava, Fault Zones	Fractured Igneous and Metamorphic (except lava), Poorly Cemented Sandstone	Moderately Cemented Sandstone, Fractured Shale	Well Cemented Sandstone	Siltstone	Unfractured Shale, Igneous and Metamorphic Rock
Representative Permeability (cm/sec) (gpd/ft^2)	>10E-2 >200	10E-2 to 10E-4 200 to 2	10E-4 to 10E-5 2 to 0.2	10E-5 to 10E-6 0.2 to 0.02	10E-6 to 10E-7 0.2 to 0.002	<10E-7 <0.002

RATING MATRIX

Overlying Soils Thickness (ft)	>100	85	60	30	10	20	10
	60-100	90	70	35	15	40	20
	30-60	94	80	40	20	10	30
	15-30	96	85	70	30	20	40
	3-15	98	90	80	60	30	10
	<3	100	95	90	80	70	50

Figure 7.4 Overlying Soils Scoring Matrix

8.0 Surface Water Compartment Completion

8.1 Existing Exposure

The Existing Exposure Category assesses the extent to which people or the environment in the vicinity of a contamination site have been exposed to a known release from the site. Existing Exposure is scored only when surface water or fish contamination is documented by direct chemical analysis and the contamination is known or strongly correlated with a site. Human exposure is scored when a surface water potable water supply intake has been contaminated so that contaminants may be entering the water supply system. Environmental surface water contamination may be documented by either surface water or sediment sample results. This equates to a determination that there has been a known release from the containment structure(s) at the site which has resulted in some level of contamination.

Scoring Procedure

Identify each contaminant and its concentration on Figure 8.1. If the contaminant has been detected at more than one sampling location or in more than one sample from a sampling location, record the highest concentration detected within the previous year.

Subtract the background level from the contaminant concentration to derive the exposure concentration for each contaminant. Using Table 7.1, select the appropriate Chemical Exposure Factor and enter on Figure 8.1. Using Table 8.1, select the appropriate Environmental Exposure Factor (surface water or sediment concentration value or irrigation/livestock value and human population values and enter on Figure 8.1. Multiply the Chemical Exposure Factor by the Environmental Exposure Factor for each chemical and record under score on Figure 8.1. Total the individual chemical scores to derive the Surface Water Subtotal.

Score Fish Consumption Risk based upon the concentration of contaminants in fish tissue which are known to be involved at the contamination site and a release to surface water is known or strongly suspected. Obtain the tissue concentration factor from the concentration ranges in Table 8.2(A) and multiply by the Fish Consumption population at risk factor in Table 8.2(B) to obtain the Fish Consumption score. If a fish consumption advisory has been issued for the affected surface water body, apply the advisory scoring procedure in Table 8.2(C) to obtain the Fish Consumption score. Record the appropriate points on Figure 8.1 and add to the Surface Water Subtotal to derive the Surface Water Existing Exposure score.

Special Conditions

Note that the total Existing Exposure score is not to exceed 350 points if all categories apply. If human drinking water supplies are affected, the maximum score is 100 points. If the drinking water

Chemical	DEL	BL	DEL - BL	CEF	PE	PF	Score
						TOTAL	

DEL	Documented Exposure Level
BL	Background Level
CEF	Chemical Exposure Factor
PE	Population Exposed
PF	Population Factor

Figure 8.1 Surface Water Compartment Existing Exposure Worksheet

Table 8.1 Surface Water Compartment Environmental Exposure Factor

Parameter	Factor
Surface Water/Sediment	5
OR	
Irrigation/Livestock	5
PLUS	
Drinking Water Population Served	
1 - 24	15
25 - 100	18
101 - 1000	20
1001 - 10,000	22
> 10,000	25

Table 8.2 Scoring for Fish Consumption Hazard

A: Fish Tissue Concentration Factor

Concentration (ppb)	Factor
<10	4
11-500	6
51-1000	8
>1000	10

B: Population at Fish Ingestion Hazard Factor

Population Size	Factor
1-50	1
50-200	3
>200	5

C: Fish Contaminant Advisory Factor

Type of Advisory	Score	
	one species	two or more species
No Advisory Issued	0	0
Restrict Consumption [1]	20	35
No Consumption [2]	35	50

1 Restrict consumption to no more than one meal per week. Children, women who are pregnant, nursing or expect to bear children should not eat any fish.

2 No one should consume the species listed in the advisory.

supply category is scored, the water or sediment contamination is not scored.

There is no scoring distinction in the number of surface water or sediment samples or number of irrigation/livestock water intakes categories. If either of these categories is affected, the base value of 5 is applied.

When determining whether a drinking water supply intake is within the area of influence of a contaminant release to surface water, draw a one-half mile radius circle around the contamination site. If a surface water body falls within the circle, extend the area of influence five miles downstream for a river or stream. For a lake, the contamination extension is identified by drawing a one-half mile arc from the point on the lakeshore closest to the contamination site and including all shoreline contained by the arc. Note that the one-half mile arc may also include homes on the opposite shoreline. Surface water intakes (including private intakes) within this area of influence are to be included when making the population impact estimates.

When estimating the drinking water population served by a contaminated surface water supply intake, use the known household populations served by the water supply system if available. If only the number of households served by the water supply system is known, estimate the population assuming that the average household consists of four people. If a public water supply system is contaminated and the direct population served is not known, determine the municipal area served by the system and apportion the population of the municipality from the most current census population data according to the area served. If separate seasonal populations are known, divide that seasonal population by two on the assumption that it is not exposed on a year-round basis.

When determining contaminant concentration, use the greatest average confirmed concentration detected at one sampling location or similar locations and consider the highest average concentration to be representative of the worst case release. Consider only those samples collected within the previous 12 months. Assume that the situation is a continuous release unless it is known that the contamination resulted from a spill. If a spill incident is known to have occurred and the incident is more than six months in the past, assume that the contaminants have left the vicinity or been diluted to undetectable levels and do not score environmental exposure unless sediment samples document that contamination remains.

If a contaminated water intake has been replaced so that the distribution system is no longer receiving contaminated water, do not score as drinking water existing exposure. If a continuous release is occurring, the surface water body is still considered contaminated and should be scored via the contaminated water, sediments or fish concentration approach.

8.2 Potential Exposure

Scoring Procedure

The scoring criteria for the Surface Water Compartment assess the probability of overland migration of contaminants to a surface water body. Only the distance to the nearest surface water body and intervening land slope is considered. Flood potential is also considered.

The distance to surface water is measured as the shortest distance from the contamination site to the nearest downgradient surface water body located in the course that overland runoff is expected to flow. A surface water body is any resource which contains water at least periodically during a year. Score the distance to the nearest surface water body using Table 8.3.

Land slope is defined as the steepness of the terrain between the contamination site and the nearest surface water body. Score the slope according to Table 8.4. If all of the surrounding terrain is higher in elevation than the site or if there are permanent dikes or other barriers to off-site flow, do not score the surface water compartment even if a surface water body lies within one-half mile of the site.

Flood potential is a measure of whether the site is susceptible to flooding which may transport contaminants off-site. Score the flood potential according to the criteria in Table 8.5.

8.3 Targets

Targets are defined as the environmental and human resources within a one-half mile radius of the contamination site which may be impacted by a release. In the Surface Water Compartment, targets are evaluated as Population at Risk for the human resources and lakes, streams, wetlands and cold water fisheries for the environmental resources.

The point distribution for lakes is dependent on size and is derived from Table 8.6. In stream scoring, intermittant flow ditches or streams score 5 points while all other streams score 10 points.

The wetland point distribution is dependent on wetland size and is derived from Table 8.7.

Warm water fisheries are considered inherent to all surface water bodies and receive no separate environmental evaluation. Cold water fisheries have been defined as special resources by the DNR Fisheries Division and water bodies supporting these fisheries receive 10 points.

Table 8.3 Scoring Distance to Nearest Surface Water Body

Distance To Surface Water	Score
more than one-half mile	0
one-quarter to one-half mile	10
one-eighth to one-quarter mile	15
less than one-eighth mile	20

Table 8.4 Scoring Terrain Slope

Average Slope	Distance To Nearest Surface Water (miles) 0 - 1/8 m	>1/8 - 1/4	>1/4
Surrounding terrain Is All Higher	0	0	0
>3%	8	6	4
3-5%	12	10	8
>5-8%	16	14	12
>8%	20	18	16

Table 8.5 Scoring Flood Potential

Flood Potential	Score
Beyond 100-Year Floodplain	0
In 100-Year Flood Plain	5
In Less Than 100-Year Floodplain	10

Table 8.6 Scoring Lakes as Targets

Size	Points
<5 acres	5
5-25 acres	10
>25 acres	15

Table 8.7 Scoring Wetlands As Targets

Size	Points
<1 acre	5
1-5 acres	10
>5 acres	15

9.0 Air Compartment Completion

9.1 Existing Exposure

The Existing Exposure category takes into consideration existing emissions to the ambient air on site and existing exposure by the human population in the target area surrounding the site. The three subcategories of Existing Exposure, On-Site Concentration, Off-Site Concentration and Off-Site Deposition are modified by a population size factor which allows consideration of the population actually exposed.

9.1.1 On-Site Concentrations

The On-Site Concentrations subcategory calculates a relative risk for deterioration of the on-site ambient air and the probability of migration of volatile organic compounds (VOCs) from the site. Air concentration data obtained by an HNU Photoionization Meter, a Century Organic Vapor Analyzer (OVA) or an equivalent instrument are acceptable minimum data. The highest level obtained in the breathing zone at the area of contamination shall be noted and used to obtain the score for air concentration at the site. Furthermore, readings shall be taken during initial investigation of the site or after emergency actions have been completed. Readings taken during cleanup activities are not representative of long term exposure and should not be used.

The approximate distance from the point at which the highest reading was obtained to the nearest site property line needs to be estimated in order to perform On-Site Concentration scoring. Figure 9.1 illustrates the manner in which On-Site Concentration scoring shall be obtained.

<u>Scoring Procedure:</u>

1. If on-site compound-specific ambient air data are available, obtain data that have been taken at or near the actual area of contamination (ie., by lagoon, stockpiles, barrels). Add the VOC concentrations of all the compounds found at the site to get the total VOCs in parts per million (ppm). If odors or measurable readings have been detected off-site (at the property line or at a nearby receptor) and determined to have originated from the site, the highest score under "On-Site Concentrations" shall be assigned for that site.

2. If compound-specific concentration data are not available, use an HNU Photoionization Meter (e.g., model PI 101) or a Century Organic Vapor Analyzer to obtain total VOC concentration at the breathing zone at or near the actual area of contamination (ie., by lagoons, stockpiles, barrels).

3. From Table 9.1 (Table of Points for On-Site Air Concentration), select the score corresponding to the appropriate on-site air concentration and distance to the nearest property line (in feet).

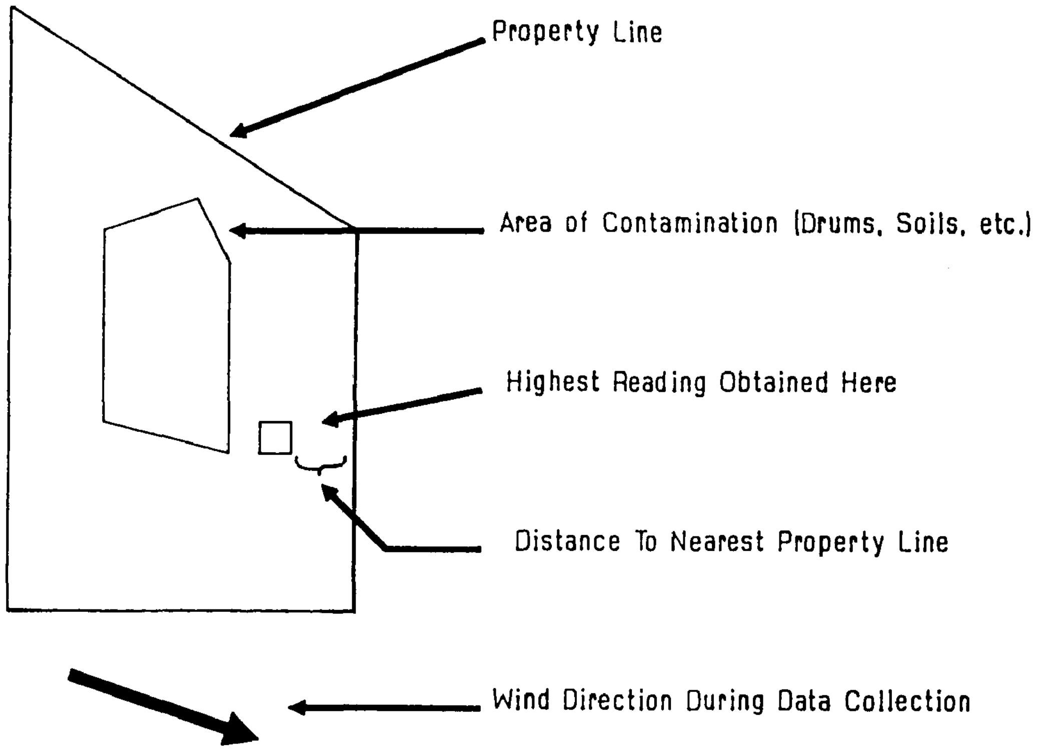


Figure 9.1 Property Line and Waste Relationships for On-Site Concentration Scoring

Table 9.1 Air Compartment Scoring for On-Site Air Concentration

On-Site Levels (ppm total VOCs)	Distance to Nearest Property Line		
	0-100 ft	101-500 ft	>500 ft
Not Detected	0	0	0
<10	8	7	6
10-25	9	8	7
>25	10	9	8

4. If there is more than one area of contamination on the site, select the highest score using the above procedure. This score will be used below.

5. Determine the population living within a one-half mile radius of the site. Using Table 9.2, obtain the Surrounding Population factor for the site.

6. Multiply the Onsite Concentration score from Table 9.1 by the surrounding population factor from Table 9.2.

7. Enter this score as the On-Site Air Concentration Score in the Site Score Sheet (Figure 1.2).

9.1.2 Off-Site Concentrations

The Off-Site Concentrations subcategory of Existing Exposure derives a relative risk for deterioration of off-site ambient air, either at the property line or at receptors, e.g., residences. It is scored if either of two situations exist:

(i) Any ambient air monitoring data collected at the site property line or at a receptor show concentrations above the local background air and can be reasonably demonstrated to be due to emission from the site.

(ii) Odors, which can be verified as having been emitted from the site, are detected at the site property line or at a receptor (residence).

If an odor or specific compound is detected at the site boundary or at an off-site residence, the On-Site concentration score is awarded the highest value (ie. a score of 10).

Scoring Procedure:

There are two options available for scoring off-site concentration: measured concentrations or odors. Measured concentrations are further divided into compound specific or total VOC methods.

A. Measured Concentrations

1. Compound Specific Data

(a) Enter the name of the compound and the highest ambient air concentration for that compound in columns A and B, respectively in Figure 9.2.

(b) List the risk-assessed ambient air values (1 in a million risk) for all of the carcinogens present on site and for which ambient air data are available, in Column C of Figure 9.2. The risk-assessed values for carcinogens are provided in Table 9.3.

(c) List the value of one percent of the Threshold Limit Value (TLV) for all of the non-carcinogens present on

Table 9.2 Air Compartment Surrounding Population Factor for Existing Exposure Scoring

Surrounding Population	Factor
1 - 12	10
13 - 24	12
25 - 100	14
101 - 250	16
251 - 500	18
501 - 750	20
751 - 1000	22
1001 - 3000	23
3001 - 10000	24
>10000	25

(A) Compound Name	(B) Highest Conc.	(C) R.A.V. or 1 % TLV	(D) Ratio of (B)/(C)	(E) Score from Table 9.4

Figure 9.2 Worksheet for Off-Site Existing Exposure Where Compound-Specific Ambient Concentrations Are Known

Table 9.3 Air Compartment Carcinogen Contaminants and Risk Assessed Concentrations

Contaminant Name	Risk-assessed value (ug/m3)
acetaldehyde	0.4
acrylonitrile	0.01
o-anisidine hydrochloride	0.04
arsenic	2.3E-04
benzene	0.14
benzo(a)pyrene	3.0E-04
bis(2-chloroethyl)ether	0.003
1,3-butadiene	0.003
1,2-butylene oxide	1.2
cadmium	5.6E-04
carbon tetrachloride	0.04
chlorinated paraffins (C10-C12;60% chlorine)	0.03
chlorodibromomethane	0.04
chloroform	0.04
3-chloro-2-methylpropene	0.03
1-chloro-2-nitrobenzene	0.21
chromium VI	8.3E-05
DDT	0.003
dichlorobenzidine	0.002
diethylhexyl phthalate	0.23
dimethylvinyl chloride	0.008
1,4-dioxane	0.18
epichlorohydrin	0.8
ethyl acrylate	0.07
ethylene dichloride	0.09
ethylene oxide	0.03
formaldehyde	0.09
hexachlorobenzene	0.002
hydrazine	0.003
methyl chloride	1.6
MBOCA	0.03
methylene chloride	1.0
2-naphthylamine	1.3E-04
PCB (Aroclor 1260)	0.001
propylene oxide	1.6
2,3,7,8-TCDD	2.3E-08
1,1,1,2-tetrachloroethane	0.07
1,1,2,2-tetrachloroethane	0.02
tetrachloroethylene	1.7
toluene diisocyanate	0.03
toxaphene	0.003
trichloroethylene	0.6
TRIS	0.002
vinyl chloride	0.4
2,6-xylidine	0.78

site and for which ambient air data are available, in Column C of Figure 9.2. The current TLV for each compound is found in the publication entitled "Threshold Limit Values and Biological Exposure Indices for [current year]."

(d) Calculate the following ratio for each compound in Figure 9.2 (note that the units must be the same for numerator and denominator).

$$\frac{\text{Ambient conc. at property line or receptor}}{\text{Conc. of 1\% TLV or risk-assessed value}}$$

(e) Enter the ratios for these compounds in Column D of Figure 9.2.

(f) From Table 9.4 select the appropriate score for the ratio of each compound and enter in Column E of Figure 9.2.

(g) Note the highest score in Column E of Figure 9.2. This score will be used below.

(h) Determine the population living within a one-half mile radius of the site. Using Table 9.2 (Air Quality Surrounding Population for Existing Exposure), obtain the surrounding population factor for the site.

(i) Multiply the highest score obtained in Column E of Figure 9.2 by the surrounding population factor from Table 9.2.

(j) Enter this score as the Off-Site Air Concentration Score in the Site Score Sheet (Figure 1.2).

2. Total VOC Data

(a) From Table 9.5, select the appropriate score for the highest VOC level measured by an OVA/HNU taken at the site property line or at receptors.

(b) Determine the population living within a one-half mile radius of the site. Using Table 9.2 (Air Quality Surrounding Population for Existing Exposure), obtain the Surrounding Population factor for the site.

(c) Multiply the highest score obtained in line (a) above by the surrounding population factor from Table 9.2.

(d) Enter this score as the Off-Site Air Concentration Score in the Site Score Sheet (Figure 1.2).

Table 9.4 Compound-Specific Concentration Factor at Site Boundary or at Receptors for Air Compartment Target Scoring

Ratio of: measured conc./[RAV or 1%TLV]	Factor
None detected	0
<10 %	3
10 % to 49 %	4
50 % to 100 %	5
>100 %	6

Table 9.5 Index for Concentrations Detected by Hand-Held Photoionization Detection Instruments at the Site Boundary or Nearby Receptors

Measured conc. of total VOC's using HNU or OVA (or equivalent)	Factor
None detected	0
<1 ppm	4
1 - 5 ppm	5
>5 ppm	6

B. Odors

1. From Table 9.6, determine the scores appropriate for the odor levels detected at various points along the site property line or receptors. If numerous odor intensities or characteristics for a given site, select the highest score for use below.

2. Determine the population living within a one-half mile radius of the site. Using Table 9.2 (Air Quality Surrounding Population for Existing Exposure), obtain the surrounding Population factor for the site.

3. Multiply the highest score obtained in line (2) above by the surrounding population factor from Table 9.2.

4. Enter this score as the Off-Site Air Concentration/Odor Score in the Site Score Sheet (Figure 1.2).

9.1.3 Off-Site Deposition

Off-site deposition, primarily evident in cases of non-volatile compounds associated with dust particles, is an indication of airborne transport of the contaminants. Concentrations of such compounds found offsite may also have resulted from trackout from the site by vehicles and which can now be further dispersed by wind or vehicle activity. In either case, the presence of these contaminants offsite indicates past or existing exposure via the air route.

Scoring Procedure:

1. Determine the circumstance(s) or locations where off-site deposition of contaminants has been verified by analytical data.

2. Using Table 9.7, select the score for the circumstance or location of off-site deposition. If off-site depositions have been found in more than one location, use the highest score. Note the highest score for use below.

3. Determine the population living within a one-half mile radius of the site. Using Table 9.2 (Air Quality Surrounding Population for Existing Exposure), obtain the surrounding population factor for the site.

4. Multiply the highest score obtained in line (2) above by the surrounding population factor from Table 9.2.

5. Enter this score as the Off-Site Deposition Score in the Site Score Sheet (Figure 1.2).

6. Note that there is only one score for any given site even if off-site deposition has been verified at several locations around the site.

Table 9.6 Detected Odor Factor for Air Compartment Target Scoring

Description	Factor
No odors detected	0
Odors detected	4
Moderate odors	5
Obnoxious/chemical-specific odors	6

Table 9.7 Off-Site Deposition Factor for Air Compartment Target Scoring

Location of off-site deposit	Factor
Off-site industrial area	1
Unused land (no residence or farm)	2
Paved road or paved shoulders	3
Gravel road or gravel shoulders	4
Crop/pasture land	5
Yard/driveway of residence	6

Note: Off-site contamination found must be due to air deposition or vehicle trackout from the site under investigation. Contamination due to other mechanisms, eg. farming practices, shall not be scored under this category.

Special Condition

If VOC contaminants are known to be leaving the site via a groundwater plume and leading to off-site surface water contamination, the maximum air compartment score shall be assigned for the site under the Off-Site Concentrations category of Existing Exposure.

9.2 Potential Exposure

The Potential Exposure portion of a site score is a relative measure of the likelihood that a site of contamination will result in contamination of the ambient air and exposure of the population.

9.2.1 Mobility

Only material on the surface including contaminated surface soil, lagoons, surface impoundments, waste piles and landfills with inadequate covers are considered in Mobility. In addition, materials in tanks, barrels or other containers on the site surface, i.e., not buried completely and which are not totally sealed are considered in this section. The score is based on the physical state and form of the material at 70 degrees F. Any material which is clearly liquid or gas will be scored as such. Sludges known to contain VOCs will be scored as liquids. An "immobile solid" is a substance that cannot be dispersed into the wind, e.g., materials in large chunks or embedded in tarry surface. However, tarry material know to contain VOCs will also be scored as liquids. A "coarsely divided solid" is at least partly composed of particles small enough to be dispersed into the air by a strong wind, e.g., sand. A "finely" divided solid" is at least partly composed of particles small enough to be dispersed into the air by a mild breeze, e.g., a dusty playground or piles containing fine particles.

Scoring Procedure:

1. Determine the score for the mobility rating factor using the worksheet in Figure 9.3.

    a. Determine the fraction of the total quantity of air materials onsite in each of the physical states listed in Figure 9.3. For example, a site may contain materials that are 50% (0.50) liquid, 25% (0.25) finely divided solid, and 25% (0.25) immobile solid. Use "Air Route Materials" (as determined in section for scoring Release Potential) in the numerator and denominator when calculating these fractions for the Air Route.

    b. For each state, multiply the quantity fraction and the base physical state score. Sum the scores from each state. This sum is the mobility score.

    c. Record this value in the Site Score Sheet, Figure 1.2.

Materials Category	Fraction of Air Compart. Materials (1)	Base Score (2)	Category Scores (1) x (2)
Gas		50	
Liquid		50	
Sludges with VOC's		50	
Finely div. solid		35	
Coarsely div. solid		15	
Immobile Solid		0	
	MOBILITY SCORE (Sum of Category Scores)		

Figure 9.3 Air Compartment Contaminant Mobility Worksheet

9.2.2 Site Activity

The Site Activity score reflects the potential for increased emissions of contaminants (volatile and non-volatile) on the surface resulting from activity on site, e.g., construction and vehicle activity resulting in disturbance of the natural soil surface and consequently causing increased emissions of volatile organic compounds present in the soil and also emissions of contaminated dust.

Scoring Procedure:

1. Determine the Site Activity Score using the matrix and worksheet in Figure 9.4.
   a. Total the quantity fraction for the three categories of solid materials to determine the total fraction of solid materials.
   b. Using the scoring matrix in Figure 9.4, determine the appropriate base score for the activities identified at the site. The score of zero in the matrix in Figure 9.4 is intended for a secure site where unauthorized vehicles or persons cannot enter. Authorized persons are those entering for the purpose of site investigation or remedial action.
   c. If more than one column applies, select the highest Base Site Activity Score from any applicable column.
   d. Multiply the quantity fraction and the base score to determine the Site Activity Score.
   e. Enter the Site Activity Score in the Site Scoring Sheet, Figure 1.2.

9.3 Targets

The only target in the air compartment is the human population surrounding the site. The potential exposure risk to the population is estimated in Section 6.0.

Site Activity Matrix:

People on Site	Light Vehicle (cars) Activity	Heavy Vehicle	Construction	Base Site Activity Score
No	None	None	No	0
Yes	<5 cars/day	--	--	10
--	>5 cars/day	<5/day	--	15
--	--	>5/day	Yes	25

Site Activity Worksheet:

Fraction of Air Route Materials in Solid Form (A)	Base Site Activity Score (B)	Site Activity Score (A) x (B)

Figure 9.4 Air Compartment Site Activity Matrix and Scoring Worksheet

Appendix B

Table 1 Summary of the 1983 Screening System Test Site Scores

Site Number	Existing Exposure	Known [a] Contam.	Popn. [b] at Risk	Unsat. [c] Zone	[d] DC/FE	Chemical Concern	Chemical Quantity	Liquid	Total 83 Screen
1	4	1,0,0	1	1	0,0	0	2	1	10
2	4	1,1,0	1	1	1,0	2	2	1	14
3	0	0,?,0	1	0	1,0	2	2	1	8
4	0	1,1,0	1	1	1,0	2	2	1	10
5	4	1,0,0	1	1	1,0	2	0	1	11
6	0	1,1,0	1	1	1,0	2	2	1	10
7	0	1,1,0	1	1	1,0	2	2	1	10
8	0	1,1,0	1	1	1,0	2	2	1	10
9	0	1,?,0	1	1	1,0	2	2	1	9
10	0	1,0,0	1	1	0,0	2	2	1	8
11	0	1,1,0	1	1	1,0	2	2	1	10
12	0	1,0,0	0	1	0,0	0	2	1	6
13	0	0,0,0	1	1	0,0	0	0	1	3
14	0	0,0,0	1	1	0,0	1	2	1	5
15	0	0,0,0	0	1	0,0	2	2	1	6
16	0	1,?,0	0	1	0,0	0	2	1	6
17	0	0,0,0	0	1	0,0	2	0	1	4
18	0	1,0,0	1	1	0,0	2	2	1	8
19	0	0,0,0	0	1	0,0	0	0	1	2
20	4	1,0,0	1	1	0,0	2	?	1	11
21	0	0,1,0	0	0	0,0	2	2	0	5
22	4	1,?,0	1	1	0,0	2	?	1	12
23	0	0,0,0	1	0	0,0	2	0	1	4
24	0	1,?,0	1	1	0,0	2	2	1	9
25	0	1,0,0	0	1	0,0	2	0	1	5
26	4	1,?,0	0	1	0,0	2	2	1	12
27	4	1,0,0	0	1	0,0	2	?	1	10
28	0	1,0,0	1	1	0,0	2	2	1	8
29	0	1,1,0	1	1	0,0	2	2	1	9
30	4	1,0,0	0	1	0,0	2	2	1	11
31	0	0,0,0	0	0	0,0	2	0	1	3
32	0	1,?,0	1	1	0,0	2	2	1	9
33	0	1,?,0	1	1	0,0	2	2	1	9
34	0	1,?,0	1	1	0,0	0	2	1	7
35	0	0,0,0	0	1	0,0	0	1	0	2
36	0	1,0,0	0	1	0,0	1	0	0	3
37	0	1,0,0	1	1	1,0	2	0	1	7
38	0	1,0,0	1	1	0,0	0	2	0	5
39	0	?,1,0	0	0	0,0	2	2	1	7
40	0	0,0,0	0	1	0,0	0	0	0	1
41	4	1,0,0	1	1	0,0	0	0	1	8
42	0	1,0,0	0	1	0,0	0	0	1	3
43	0	?,1,0	1	1	0,0	2	2	1	9
44	4	0,1,0	0	0	0,0	2	0	1	8
45	0	?,?,0	0	1	1,0	2	2	0	7
46	0	?,1,0	1	1	0,0	2	2	0	8
47	4	1,0,0	0	1	0,0	2	0	1	9
48	0	1,1,0	1	1	0,0	2	2	1	9
49	0	1,1,0	1	1	?,0	2	2	1	7
50	0	0,1,0	0	0	1,0	2	2	0	6

[a] Known Contamination   Ground Water, Surface Water, Air

[b] Population at Risk

[c] Unsaturated Zone

[d] Direct Contact/Fire and Explosion

Table 2 Summary of the Revised Screening System Test Site Scores

Site Number	Environmental Contamination(max 20) Pot. a	Susp. b	Conf. c	Human d	Mobility	Sens. e Environ.	Popn. f at Risk	Inst. g Popn.	Toxicity ID K Q h	/ ID E Q i	Quantity WC E Q j	R Total Screen
1	A 2, SW 2	S 4	GW 6	0	6	0	1	0	0	0	9	30
2	A 2	S 4	GW 6 SW 6	0	3	0	1	1	0	12	0	35
3	Gw 2 SW 2	A 4	0	S 8	3	0	5	1	0	15	0	40
4	0	S 4	GW 6 Sw 6	0	6	0	1	0	0	0	9	32
5	SW 2	0	S 6 Gw 6	0	3	0	1	0	9	0	0	27
6	0	0	S 6 SW 6	GW 6	3	3	3	0	0	0	15	42
7	0	0	S 6 SW 6	GW 6	6	3	3	0	0	13	0	43
8	0	A 4	S 6 SW 6	GW 6	3	3	3	1	0	0	13	45
9	SW 1	0	S 6 GW 6	0	6	0	3	1	0	11	0	34
10	SW 1	0	S 6 GW 6	0	3	0	0	1	0	0	7	24
11			S 6 GW 6	SW 8	3	0	1	0	0	0	11	35
12	A 1	0	S 6 GW 6	0	6	0	0	0	0	0	5	24
13	GW 2	SW 4	S 6	0	6	0	3	0	0	0	5	26
14	A 2 SW 2	S4 GW 4	0	0	3	0	3	1	0	0	9	28
15	0	S 4 SW 4	0	0	3	0	1	0	0	0	7	21
16	0	SW 4	S 6 GW 6	0	6	0	0	0	0	0	11	37
17	GW 2	0	S 6	0	3	0	5	1	0	0	7	24
18	A 2 GW 2	0	S 6	0	3	0	3	1	0	0	9	26
19	0	S 4	0	0	3	0	5	1	0	0	7	20
20	0	S 4	0	GW 8	3	0	3	0	0	9	0	27
21	A 2	SW 4	S 6	0	0	3	1	0	0	13	0	29
22	SW 2	S 4	0	GW 8	3	0	3	1	0	9	0	30
23	SW 2	S 4	GW 6	0	3	0	0	0	0	11	0	26
24	SW 2 GW 2	A 4	S 6	0	3	0	1	1	0	11	0	31
25	GW 2	S 4	0	0	0	0	0	0	0	11	0	17
26	SW 2	S 4	0	GW 8	3	0	0	1	0	11	0	29
27	0	S 4	0	GW 8	3	0	0	0	0	9	0	24
28	0	S 4	GW 6	0	3	0	5	0	0	11	0	29
29	A 2	SW 6	S 6 GW 6	0	3	0	3	0	0	13	0	39
30	SW 2	S 4	0	GW 8	3	0	0	1	0	13	0	31
31	0	SW 4 S 4	0	0	6	0	3	1	0	0	11	29
32	A 2	SW 4	S 6 GW 6	0	6	0	5	0	0	0	11	40
33	SW 2	0	GW 6	0	6	0	3	1	0	0	13	31
34	SW 2	0	GW 6	0	3	0	3	0	0	0	7	21
35	SW 2 GW 2	0	0	0	3	0	0	0	0	0	5	12

Table 2 (cont'd.)

Site	Environmental Contamination(nax 20)					Sens. e	Popn. f	Inst. g	Toxicity	/	Quantity	Total
Number	Pot. a	Susp. b	Conf. c	Human d	Mobility	Environ.	at Risk	Popn.	ID K Q h	ID E Q i	WC E Q j R	Screen
35	SW 2 GW 2	0	0	0	3	0	0	0	0	0	5	12
36	SW 2	GW 4	0	0	3	0	1	1	0	0	7	18
37	SW 2	0	S 6 GW 6	0	3	0	1	1	0	15	0	34
38	SW 2	0	S 6 GW 6	0	6	0	5	1	0	15	0	41
39	SW 2	0	S6	0	0	0	0	0	15	0	0	23
40	SW 2 GW 2	S 4	0	0	6	0	0	0	0	0	3	17
41	SW 2	S 4	0	GW 8	6	0	3	1	7	0	0	31
42	SW 2	S4 GW 4	0	0	6	0	0	0	0	0	5	21
43	0	0	0	SW 8	3	3	5	1	0	15	0	35
44	A 2 GW 2	S 4	SW 6	0	6	3	0	0	0	0	7	30
45	A 2	SW 4 GW 4	S 6	0	6	3	0	0	0	3	11	36
46	^0	GW 4	SW 6	0	3	3	3	1	0	15	0	35
47	SW 2	0	S 6	GW 8	0	3	0	0	0	0	13	32
48	0	S 4 SW 4	GW 6	0	3	3	3	0	0	0	11	34
49	0	0	S 6 SW 6	GW 8	3	3	3	1	11	0	0	41
50	GW 2	0	S6	SW 8	0	0	1	1	15	0	0	33

a = Potential contamination, A = Air, S = Soils, SW = Surface Water, GW = Ground Water
b = Suspected Contam,inatio "
c = confirmed Contamination "
d = Human Exposure "
e = Sensitive Environment
f = Population at Risk
g = Institutional Population
h = Identified Chemicals, Known Quantities
i = Identified Chemicals, Estimated Quantities
j = Waste Characterization, Estimated Quantities

Table 3 Summary of the 1983 Site Assessment System Test Site Scores

Site	Ground Water Route							Surface Water Route							
Number	Rel Pot	Usat Zone	Popn Risk	Sat Zone	PE Score	Fx Exp	Rte Score	Rel Pot	Distance	Slope	Flood Pot	Popn Risk	DW Popn	Wetland	CW Fish
1	1.5	30	75	20	125	8	196	1.5	40	10	0	35	0	0	0
2	0.97	92	85	50	220	0	220	1.02	40	20	20	85	0	0	15
3	1.25	2	0	60	78	0	78	1.25	40	20	0	85	0	0	10
4	1.25	30	50	40	150	0	150	1.25	10	6	0	30	0	0	0
5	2.0	92	85	50	454	12	466	2.0	10	24	0	55	0	0	15
6	2.0	98	0	50	296	0	296	1.74	40	20	20	50	0	10	0
7	2.0	100	0	50	300	0	300	2.0	40	10	20	55	0	10	15
8	1.79	92	60	30	326	0	326	1.74	40	10	20	60	0	10	15
9	2.0	90	0	50	280	0	280	2.0	40	40	10	90	0	0	15
10	2.0	90	35	50	350	0	350	2.0 .	20	16	0	55	0	0	0
11	0.15	80	0	50	20	0	20	1.58	40	0	20	50	0	0	15
12	1.0	70	20	50	140	0	140	0	0	0	0	0	0	0	0
13	2.0	70	0	20	180	0	180	2.0	40	30	20	35	0	0	15
14	2.0	50	85	40	350	0	350	2.0	40	10	10	50	0	0	0
15	2.0	60	45	30	270	0	270	2.0	40	10	20	20	45	10	0
16	1.89	96	70	60	427	0	427	1.89	40	10	0	15	0	0	15
17	2.0	40	0	40	160	0	160	0	0	0	0	0	0	0	0
18	1.25	90	90	30	263	0	263	1.25	10	8	0	55	0	0	0
19	1.25	20	0	50	88	0	88	0	0	0	0	0	0	0	0
20	2.0	98	75	50	446	6	452	0	0	0	0	0	0	0	0
21	1.5	70	0	10	120	0	120	1.5	40	40	20	60	0	10	0
22	2.0	50	85	50	370	4	374	0	0	0	0	0	0	0	0
23	2.0	50	70	50	340	0	340	2.0	40	20	20	30	0	10	0
24	1.66	20	20	30	116	0	116	1.66	40	10	20	70	0	10	0
25	2.0	80	60	60	400	0	400	2.0	10	24	0	25	0	0	0
26	2.0	50	90	60	400	2	402	2.0	40	20	10	55	0	0	15
27	2.0	8	65	60	266	32	298	0	0	0	0	0	0	0	0
28	2.0	90	35	30	310	0	310	0	0	0	0	0	0	0	0
29	2.0	90	60	30	360	0	360	2.0	40	10	0	30	0	10	0
30	2.0	90	70	50	420	2	422	2.0	40	10	0	35	0	10	15
31	1.75	20	40	50	193	0	193	1.75	40	30	10	65	0	0	0
32	1.09	96	40	50	203	0	203	0.51	40	20	0	20	0	10	15
33	1.5	40	85	30	233	0	233	0	0	0	0	0	0	0	0
34	1.25	30	0	50	100	0	100	0	0	0	0	0	0	0	0
25	1.25	50	40	50	175	0	175	1.25	40	30	10	10	0	10	15
36	1.25	90	40	50	225	0	225	1.25	20	32	0	10	0	10	0
37	2.0	40	90	30	320	0	320	2.0	20	0	0	65	0	0	0
38	2.0	4	0	20	48	0	48	1.25	20	16	10	60	0	0	0
39	1.18	2	35	30	79	0	79	1.18	40	6	0	10	0	0	0
40	1.0	30	65	50	145	0	145	1.0	20	16	0	45	0	10	15
41	2.0	80	90	50	440	0	440	2.0	40	40	0	65	0	10	15
42	2.0	80	75	50	410	0	410	2.0	40	30	0	35	0	10	0
43	0	0	0	0	0	0	0	1.75	40	40	20	100	0	10	0
44	2.0	50	55	40	290	0	290	2.0	40	20	10	30	0	10	0
45	1.5	90	0	50	210	0	210	1.5	40	40	20	55	0	10	15
46	1.63	70	90	30	310	0	310	1.63	40	40	20	90	0	10	0
47	2.0	30	50	30	220	0	220	2.0	40	40	0	15	0	10	0
48	1.63	90	0	10	163	0	163	1.63	40	40	20	60	0	10	0
49	2.0	40	90	40	340	12	352	2.0	40	40	0	70	0	10	0
50	0	0	0	0	0	0	0	1.75	40	40	20	80	0	10	0

Table 3 (cont'd.)

				Air Route							Direct Contact Route				
WW Fish PE	Score	Ex Exp	Rte Score	Rel Pot	Mobility	Site Act	Popn Risk PE	Score	Ex Exp	Rte Score	Rel Pot	Access	Attract	Popn RiskPE	Score
10	143	0	143	0.05	70	29	60	8	0	8	1.5	40	30	35	158
0	184	0	184	0	0	0	0	0	0	0	0	0	0	0	0
0	194	0	194	0.05	50	30	100	9	250	309	1.25	61	20	85	208
0	60	0	60	0.05	30	20	50	5	0	5	1.25	0	10	45	75
0	208	0	208	0	0	0	0	0	0	0	0	0	0	0	0
10	261	0	261	0.66	70	0	60	43	0	43	0	0	0	0	0
0	300	0	300	2.0	70	0	70	280	90	370	2.0	40	20	55	230
0	270	0	270	0.05	70	0	75	7	0	7	0	0	0	0	0
0	390	0	390	0	0	0	0	0	0	0	0	0	0	0	0
10	202	0	202	0	0	0	0	0	0	0	0	0	0	0	0
0	198	50	248	0.10	69	1	70	14	0	14	1.53	40	10	50	153
0	0	0	0	0.05	30	20	10	3	0	3	1.0	20	0	10	30
0	339	0	280	0	0	0	0	0	0	0	2.0	20	10	35	65
10	240	0	240	0.04	30	20	70	5	0	5	2.0	32	10	50	184
10	310	0	310	0.04	70	3	45	5	0	5	2.0	61	30	20	222
10	170	0	170	0.05	15	10	35	3	0	3	1.89	40	10	15	123
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	104	0	104	0.03	30	20	70	4	0	4	1.25	20	0	35	69
0	0	0	0	0.13	70	20	85	22	0	22	1.25	20	30	75	156
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	270	0	270	0.02	30	20	70	2	0	2	1.5	40	20	60	180
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	260	0	260	0	0	0	0	0	0	0	0	0	0	0	0
10	266	0	266	0.22	70	3	85	35	0	35	1.66	52	40	65	261
10	138	0	138	0	0	0	0	0	0	0	0	0	0	0	0
0	280	0	280	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	200	0	200	0.04	30	20	44	4	0	4	2.0	29	0	44	146
0	220	0	220	0	0	0	0	0	0	0	0	0	0	0	0
10	271	0	271	0	0	0	0	0	0	0	1.75	20	20	65	184
0	54	0	54	0.2	62	20	45	25	30	55	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	144	0	144	0.01	30	20	30	1	0	1	1.25	12	10	10	40
10	103	0	103	0.01	30	20	25	1	0	1	1.25	12	10	10	40
10	190	0	190	0	0	0	0	0	0	0	2.0	20	10	65	190
10	145	0	145	0	0	0	0	0	0	0	1.25	20	0	60	100
0	66	0	66	0.47	64	10	30	49	0	49	1.18	80	20	10	130
0	106	0	106	0	0	0	0	0	0	0	1.0	20	10	45	75
0	340	0	340	0	0	0	0	0	0	0	0	0	0	0	0
10	250	0	250	0	0	0	0	0	0	0	0	0	0	0	0
10	385	50	435	0	0	0	0	0	0	0	0	0	0	0	0
10	240	0	240	0.02	30	10	50	2	0	2	2.0	20	10	30	120
0	270	0	270	0.05	30	10	70	6	0	6	1.5	40	30	55	188
10	342	50	392	0.05	30	20	85	7	0	7	0.88	40	30	90	141
0	210	0	210	0.05	70	0	50	6	0	6	2.0	40	20	15	150
10	293	0	293	0	0	0	0	0	0	0	1.63	40	20	60	196
10	340	0	340	1.66	70	0	90	266	0	266	1.66	20	20	70	183
10	350	50	400	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (cont'd.)

	Fire and Explosion Route							Route	Chemical	Total
Rte Score	Rel Pot	Ignition	Waste	SepPopn Risk	Wetland	PE Score	Rte Score	Subscore	Hazard	Score
158	0	0	0	0	0	0	0	290	150	440
0	0	0	0	0	0	0	0	287	400	687
208	0	0	0	0	0	0	0	427	475	902
75	1.25	0	0	50	0	63	63	189	100	289
0	0	0	0	0	0	0	0	510	0	510
0	0	0	0	0	0	0	0	397	450	847
230	0	0	0	0	0	0	0	608	450	1058
0	0.05	0	0	75	10	4	4	424	525	949
0	0	0	0	0	0	0	0	480	250	730
0	0	0	0	0	0	0	0	404	100	504
153	0	0	0	0	0	0	0	292	442	734
30	0	0	0	0	0	0	0	143	100	243
65	0	0	0	0	0	0	0	339	50	389
184	0	0	0	0	0	0	0	463	100	563
222	0	0	0	0	0	0	0	467	50	517
123	0	0	0	0	0	0	0	476	450	926
0	0	0	0	0	0	0	0	160	100	260
69	0	0	0	0	0	0	0	291	150	441
156	0	0	0	0	0	0	0	180	150	330
0	0	0	0	0	0	0	0	452	320	772
180	0	0	0	0	0	0	0	346	450	796
0	0	0	0	0	0	0	0	374	360	734
0	0	0	0	0	0	0	0	428	450	878
261	0.08	50	0	85	10	12	12	391	500	891
0	0	0	0	0	0	0	0	423	150	573
0	0	0	0	0	0	0	0	490	250	740
0	0	0	0	0	0	0	0	298	100	398
0	0	0	0	0	0	0	0	310	200	510
146	0	0	0	0	0	0	0	437	400	837
0	0	0	0	0	0	0	0	476	350	826
184	0	0	0	0	0	0	0	380	150	530
0	0	0	0	0	0	0	0	217	450	667
0	0	0	0	0	0	0	0	233	450	683
0	0	0	0	0	0	0	0	100	50	150
40	0	0	0	0	0	0	0	230	50	280
40	0	0	0	0	0	0	0	250	50	300
190	0	0	0	0	0	0	0	418	450	868
100	0	0	0	0	0	0	0	183	50	233
130	0.42	30	50	30	0	46	46	179	525	704
75	0	0	0	0	0	0	0	195	0	195
0	0	0	0	0	0	0	0	556	50	606
0	0	0	0	0	0	0	0	480	100	580
0	0	0	0	0	0	0	0	435	450	885
120	0	0	0	0	0	0	0	395	450	845
188	1.5	50	30	70	10	240	240	458	525	983
141	0	0	0	0	0	0	0	519	450	969
150	0	0	0	0	0	0	0	339	450	789
196	0	0	0	0	0	0	0	0	450	838
183	0	0	0	0	0	0	0	586	300	886
0	0	0	0	0	0	0	0	400	450	850

Table 4 Summary of the Revised Site Assessment System Test Site Scores

Site	Air Compartment									Compmnt	Ground Water Compa				
Number	Mig Pot	Mobility	Site Act	Pop Risk	PE Score	OnSite C	Offsite C	Soil Dep Ex	Exp Sc	Score	Mig Pot	Over Soil	Use Aquif	Pop Risk	PE Score
1	0.018	50	10	55	2	0	0	0	0	2	1.73	3	85	55	247
2	0	0	0	0	0	0	0	0	0	0	0.97	98	80	0	345
3	0.05	35	15	105	78	0	0	150	150	225	0.8	1	100	0	81
4	1.25	35	10	60	4.2	0	0	0	0	4.2	1.25	63	45	60	262
5	1.55	1.5	1.5	50	106	0	0	0	0	106	1.25	95	42	50	374
6	0.71	26	7	70	73	0	0	0	0	73	1.64	90	50	0	230
7	0.27	50	15	90	42	184	150	0	334	376	2.0	98	80	0	356
8	0.06	24	10	70	6	250	96	0	346	352	1.82	92	60	90	440
9	0.2	50	10	100	32	0	0	0	0	32	2.0	90	50	0	280
10	0	0	0	0	0	0	0	0	0	0	2.0	98	56	40	388
11	0	0	0	0	0	0	0	0	0	0	1.69	98	60	0	267
12	0	0	0	0	0	0	0	0	0	0	1.5	94	80	20	291
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0.015	15	15	90	2	0	0	0	0	2	1.5	25	43	70	207
15	1.75	50	15	45	193	0	0	0	0	193	1.75	60	30	45	236
16	1.13	50	10	40	113	0	0	0	0	113	2.0	96	100	60	512
17	0	0	0	0	0	0	0	0	0	0	0.6	30	40	0	84
18	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
19	0.09	35	15	100	14	0	0	0	0	14	1.56	30	60	0	140
20	0	0	0	0	0	0	0	0	0	0	2.0	98	60	60	436
21	0.01	15	10	90	1	0	0	46	46	47	1.75	50	15	0	114
22	0	0	0	0	0	0	0	0	0	0	2.0	84	50	65	398
23	0	0	0	0	0	0	0	0	0	0	1.6	60	60	60	288
24	0.22	35	25	95	34	0	0	0	0	34	1.66	30	30	20	133
25	0	0	0	0	0	0	0	0	0	0	2.0	96	20	50	332
26	0	0	0	0	0	0	0	0	0	0	2.0	85	80	85	500
27	0	0	0	0	0	0	0	0	0	0	1.45	4	80	50	194
28	0	0	0	0	0	0	0	0	0	0	2.0	95	38	0	266
29	0.5	15	15	80	55	0	0	0	0	55	2.0	90	30	30	300
30	0.4	35	10	50	38	0	0	0	0	38	2.0	74	40	50	328
31	0.02	50	15	100	3	0	0	0	0	3	1.88	47	40	35	229
32	1.2	50	15	40	126	0	0	0	0	126	2.0	98	40	40	356
33	0	0	0	0	0	0	0	0	0	0	1.5	63	44	70	266
34	0	0	0	0	0	0	0	0	0	0	1.5	43	80	40	245
35	0	0	0	0	0	0	0	0	0	0	1.56	43	60	40	223
36	0	0	0	0	0	0	0	0	0	0	1.56	45	80	40	257
37	0	0	0	0	0	0	0	0	0	0	1.95	87	60	95	472
38	0.02	35	10	95	3	0	0	0	0	3	1.56	4	40	0	69
39	0.01	15	15	90	1	0	0	0	0	1	0.7	1	80	40	85
40	0	0	0	0	0	0	0	0	0	0	1.5	57	60	50	251
41	0	0	0	0	0	0	0	0	0	0	2.0	96	60	95	502
42	0	0	0	0	0	0	0	0	0	0	2.0	96	60	60	432
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	1.23	81	54	40	215
45	0.08	35	10	95	11	0	0	0	0	11	1.88	98	80	0	335
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	1.38	35	15	40	124	0	0	0	0	124	1.5	28	39	40	161
48	0	0	0	0	0	0	0	0	0	0	1.5	90	40	0	195
49	0.09	35	10	100	128	0	0	96	96	224	2.0	80	60	95	470
50	0	0	0	0	0	0	0	0	0	0	1.6	70	50	100	352

Table 4 (cont'd.)

rtment				Compart											Surface Water Compartment
Mon Well	D W Wells	Irrig Wel	Ex Exp Sc	Score	Mig Pot	Dist S W	Site Slop	Flood Pot	Fish Inge	Lake	Stream	Wetland	Cold W Fi	DW Pop Ri	Bath PopR
0	120	0	120	367	1.73	20	8	0	50	0	10	15	0	60	40
30	0	0	0	375	1.15	20	12	10	60	15	10	0	0	0	50
0	0	0	0	81	1.2	10	0	0	60	0	10	0	0	0	55
45	0	0	45	373	1.25	10	12	0	40	0	10	0	0	0	80
75	0	0	75	449	0.6	10	6	0	40	15	0	0	0	0	5
75	0	0	75	305	1.97	20	20	10	50	15	10	15	0	0	50
125	0	0	125	481	2.0	20	8	10	50	10	10	15	0	0	50
25	60	0	85	525	2.0	20	20	10	30	0	10	15	0	0	30
125	0	0	125	405	1.32	20	20	5	50	15	10	0	10	0	50
50	0	0	50	438	1.0	10	6	0	30	0	10	15	0	0	35
90	0	0	90	357	1.81	20	16	5	50	0	10	10	10	0	50
60	0	0	60	351	1.25	10	4	0	30	0	10	10	10	0	35
0	0	0	0	0	2.0	20	20	10	50	15	10	0	10	0	50
0	0	0	0	207	2.0	20	8	5	50	0	10	0	0	0	50
0	0	0	0	236	2.0	20	12	10	50	0	10	15	0	65	50
75	0	0	75	587	1.5	20	8	0	50	10	10	0	10	0	50
0	0	0	0	84	0	0	0	0	0	0	0	0	0	0	0
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
0	0	0	0	140	0	0	0	0	0	0	0	0	0	0	0
0	250	0	250	686	2.0	10	12	0	50	15	10	15	10	0	50
0	0	0	0	114	2.0	20	8	10	50	15	10	15	0	0	30
0	210	0	210	608	2.0	20	20	5	50	0	10	15	0	0	50
0	250	0	250	538	2.0	20	12	5	20	0	10	15	0	0	30
0	0	0	0	133	2.0	20	12	5	50	15	0	15	0	0	50
0	0	0	0	332	2.0	10	16	0	30	0	10	0	0	0	35
0	30	0	30	530	2.0	20	12	5	50	0	10	10	10	0	50
0	250	0	250	444	1.21	20	12	0	0	0	0	15	0	0	0
0	90	0	90	356	1.35	20	12	5	0	0	10	0	0	0	40
125	0	0	125	425	1.2	20	8	0	40	0	10	10	0	0	40
0	30	0	30	358	2.0	10	12	0	30	15	10	15	10	0	35
0	0	0	0	229	2.0	20	16	5	50	15	10	0	0	0	50
0	0	0	0	356	1.5	20	12	5	50	0	10	15	10	0	50
120	0	0	120	386	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	245	2.0	15	10	5	50	0	10	15	0	90	50
0	0	0	0	223	1.88	20	16	5	40	0	10	15	10	0	45
0	0	0	0	257	2.0	20	20	0	30	0	10	15	0	0	35
125	0	0	125	597	1.95	15	6	0	40	0	10	0	10	0	45
120	0	0	120	189	1.88	10	8	5	50	0	10	0	0	0	50
0	0	0	0	85	0.7	10	4	0	50	5	10	10	0	0	50
0	0	0	0	251	1.5	15	10	0	60	0	10	10	10	0	40
0	150	0	150	652	2.0	20	20	0	50	15	0	0	10	0	50
0	0	0	0	432	2.0	20	16	0	30	15	0	10	0	0	35
0	0	0	0	0	1.2	20	12	10	50	15	10	15	10	100	50
0	0	0	0	215	2.0	20	12	5	20	0	10	15	0	0	35
125	0	0	125	460	2.0	20	20	10	50	0	10	15	10	100	50
0	0	0	0	0	0.9	20	20	10	50	0	10	15	0	0	50
125	0	0	125	286	2.0	20	20	0	0	0	5	15	0	0	10
125	0	0	125	320	0.98	20	8	10	50	15	10	15	0	0	50
125	0	0	125	595	2.0	20	20	0	50	15	10	10	0	0	50
0	0	0	0	352	2.0	20	20	10	50	15	10	15	0	0	50

Table 4 (cont'd.)

P E Score	Env Exp	S D W Pop	Fish Advi	Irr WaterEx	Exp Sc	Compmnt Score	Compmnt Subscore	Chemical Hazard	Total Score
247	40	0	0	0	40	287	466	255	691
354	50	0	0	0	0	404	551	871	1422
162	50	0	20	0	70	232	333	1000	1333
296	0	0	0	0	0	245	476	85	561
91	0	0	0	0	0	91	470	51	521
374	20	0	0	0	20	394	504	900	1404
346	50	0	0	0	50	396	728	1300	2028
270	10	0	0	0	10	280	691	1300	1991
238	0	0	0	0	0	238	471	1300	1771
212	0	0	0	0	0	212	487	322	809
310	90	0	0	0	90	400	536	1300	1836
136	0	0	0	0	0	136	376	532	908
370	50	0	0	0	50	420	420	81	501
286	0	0	0	0	0	286	353	68	421
464	0	0	0	0	0	464	555	15	570
237	0	0	0	0	0	237	643	1000	1643
0	0	0	0	0	0	0	84	212	296
L	L	L	L	L	L	L	L	L	542
0	0	0	0	0	0	0	141	127	268
344	0	0	0	0	0	0	344	217	984
316	0	0	0	0	0	316	339	1300	1639
340	0	0	0	0	0	340	697	222	919
224	0	0	0	0	0	224	583	443	1026
334	0	0	0	0	0	334	361	1300	1661
202	0	0	0	0	0	202	389	595	984
334	0	0	0	0	0	334	626	1300	1926
57	0	0	0	0	0	57	448	1300	1748
118	0	0	0	0	0	118	375	1300	1675
154	40	0	0	0	40	194	471	1300	1771
276	0	0	0	0	0	276	454	1300	1754
332	0	0	0	0	0	332	404	165	569
258	0	0	0	0	0	258	457	293	750
0	0	0	0	0	0	0	386	130	516
490	0	0	0	0	0	490	548	165	713
303	0	0	0	0	0	303	376	41	417
260	0	0	0	0	0	260	366	61	427
126	0	0	0	0	0	126	610	1300	1910
250	50	0	0	0	50	300	355	56	411
97	50	0	0	0	50	147	170	1117	1287
233	0	0	0	0	0	233	342	16	358
350	0	0	0	0	0	350	740	26	766
252	0	0	0	0	0	252	500	105	605
292	0	250	0	0	250	542	542	1000	1542
234	0	0	0	0	0	234	318	1300	1618
570	50	0	0	0	50	620	772	270	1042
158	50	0	50	50	150	308	308	1000	1308
140	0	0	0	0	0	140	341	330	671
174	0	0	35	0	35	209	382	200	582
350	30	0	0	0	30	380	741	1000	1741
380	50	0	35	0	80	465	583	1000	1583

SITE DESCRIPTION

Sanitary Landfill Area No. 1
Smith Creek Road
Smiths Creek, St. Clair Co.

Site Number 1

RSAS Screen: 30   RSAS Score: 691   SAS Screen: 10   SAS Score: 440

This is an operating landfill operated by St. Clair County Road Commission, located just east of the Smiths Creek city limits. The fill area covers 50 acres in the northwest corner of the property. Mostly general refuse is accepted, along with some salt food processing wastes, dairy wastes and paper products waste. No leachate collection system is present - leachate flows from the fill over the surface to a pond where it is allowed to evaporate. A new 30 acre fill will have collection system, utilizing this pond and phasing out the evaporation practice.

Area drinking water wells are completed at depths ranging from 35 to 50 feet below grade. Soils are silty clay under one to two feet of clayey topsoil. Aquifer is greater than 10 feet in thickness under the clay, consisting of sand and gravel. A water table aquifer is found from 14 to 16 feet below grade. In 1979, residential wells nearby were tested and phenols (1.4 ppb, cyanide 200 ppb, and chromium, 20 ppb) were found. Phenols were also found in the landfill well, which has been plugged. Approximately 192 people live within the 1/2 mile radius downgradient from the site with an additional 40 people upgradient.

Walvin Drain, tributary to the Pine River 1 1/2 miles away, runs through the fill area. The drain contains water throughout the year.

SITE DESCRIPTION

Peerless Plating
2554 Getty Street
Muskegon, Muskegon Co., 49444

Site Number 2

RSAS Screen: 35 RSAS Score: 1422 SAS Screen: 14 SAS Score: 687

Peerles Plating is an inactive electroplating facility located in Muskegon County. Plating wastes were discharged to 0.5 acre lagoons on the property. Numerous chemical spills occurred both indoors and outdoors. The lagoon contents and soils surrounding the lagoons have been removed and were then backfilled and capped with clay. During the fall of 1983 the U.S. EPA conducted an immediate removal at this site. These operations included drum removal, tank and pipe draining, decontamination of vats, sludge removal from sewer lines, and stabilization of the nitric acid tank.

Groundwater discharge to Little Black Creek approximately 150 feet from the lagoons. Levels of contaminants found in Little Black Creek were 46 ppm cadmium, 190 ppm chromium, 150 ppm copper, 220 ppm nickel, 740 ppm lead and 440 ppm zinc. Groundwater was found to contain 4.0 ppb trichloroethylene at Peerless Plating's well and at a nearby hardware store.

Are drinking water is supplied by a municipal system with wells and surface water intake outside the 1/2 mile radius. Approximately 600 people reside within the 1/2 mile radius, with on school just inside the 1/2 mile limit.

Site soils consist of 5 to 10 feet of sand and gravel overlying greater than 80 feet of medium sand. No confining layers have been identified.

SITE DESCRIPTION

Carter Industrial Inc.
4690 Humboldt Road
Detroit, Wayne Co., 48208

Site Number 3

RSAS Screen: 40 RSAS Score: 1333 SAS Screen: 8 SAS Score: 902

Carter Industrial, Inc. was an industrial scrap metal yard located in Detroit. The operation involved scrap metal and equipment dismantling and some metal processing for resale. This site is at the north end of Humboldt Road which dead-ends into the yard. The property borders the road on both sides and abutts the Grand Trunk Western R.R. to the north and west and a public alley to the east. On-site facilities included a furnace for aluminum melting, a furnace for copper melting, a brick warehouse, and an office building. Numerous unsheltered piles of scrap metal and equipment were found throughout the yard.

On July 3, 1984, fire broke out on the West side of the property in an area of wooden pallets and scrap iron mounds. Several transformers were noted in the area of the fire and evidence of oil was found near the fire area and near the base of three large transformers.

Barrels of used PCB fluids were stored on-site in an around scrap metal piles and oil leaking from them had PCB concentrations as high as 500,000 parts per million (ppm). Sampling from the public alley east of Carter Industrial revealed PCB concentrations of up to 96,000 ppm in soil. The alley is adjacent to a residential neighborhood and both footprints and dog prints were evident as well as signs of bicycle and truck traffic. Samples taken from residential backyards abutting the alley revealed PCB concentrations as high as 1,800 ppb.

The U.S. EPA carried out an emergency removal action in late 1986. Private yards, streets, and alleys were cleaned with a high-power vacuum. Soil and refuse were piled and stored on-site. Alleys and streets were repaved with 2 feet of asphalt and the site was fenced. Transformers and drums were removed to a facility regulated under the Toxic Substances Control Act.

Area drinking water is supplied by a municipal system with a surface water source outside the 1/2 mile radius. No surface water exists within the area while the population is approximately 10,660. Several schools are nearby.

SITE DESCRIPTION

Oliver's Sanitary LF
9873 Tuscola Road
Clio, Tuscola, Michigan 48420

Site Number 4

RSAS Screen: 32 RSAS Score: 478 SAS Screen: 10 SAS Score: 289

Oliver's Sanitary Landfill began operation approximately 40 years ago, allegedly receiving domestic and commercial wastes from the landfill owner's refuse hauling service. This landfill is 30 acres in size, although there are reports that waste disposal has extended outside of the boundaries of the permitted area.

The landfill is situated in sandy surficial soils and is partially in the water table. The sand layer is 11 to 35 feet thick under a 1-2 foot layer of very sandy loam top soil. An 11 to 64 foot clay layer, at times interspersed with 2-5 feet of gravel, overlies bedrock consisting of shale and sandstone. Most private wells are completed in the sandstone. Ground and surface water contamination - both on and off the site - have been confirmed. Elevated levels of lead (65 ppb), chromium (50 ppb), cadmium (290 ppb), zinc (17 ppm) and TOC (4-250 ppm) have been detected in the water table aquifer monitoring wells on-site. There are at least 50 homes located within one-half mile of this site, but there have been no indications of impact to private wells. No schools or hospitals are located within the 1/2 mile radius.

Surface water ponding is present and an intermittent stream runs through the property. Leachate generation occurs throughout the site. A collection ditch leads to an unlined collection pond which discharges to the stream.

SITE DESCRIPTION

Washout Laundry
200 Deyarmond
Mio, Oscoda Co., 48647

Site Number 5

RSAS Screen: 27 RSAS Score: 521 SAS Screen: 11 SAS Score: 510/12

The Washout Laundry site, which includes a laundromat and a dry cleaners, is located in Big Creek Township in the Village of Mio. Early in the Spring of 1979, a discharge of laundry wastewater to the ground was first noted behind the laundromat building. Later in October of 1979, a hauling truck was parked 200 feet behind the laundromat and the waste contents of the truck were discharged to the ground surface. This occurred again in mid-April, 1980. A cement holding tank (40,000 gallon capacity) located behind the laundromat was found leaking. It is suspected that the walls of the tank are cracked. The discharge flowing into the tank was sampled and the sample test indicated tetrachloroethylene (500 ppb).

Groundwater contamination has been identified in the immediate area which is believed to have originated from the laundromat. June 1985 sample results taken from drinking supply wells located north of the building indicate contamination of tetrachloroethylene in two wells, one being a residential well and the other being a non-community well, a church. Both of the wells are located downgradient from this facility. Groundwater flow direction is in a north of northeast direction.

The church well test results taken on June 25, 1985, indicate contaminations by tetrachloroethylene (327 ppb), trichloroethylene (3 ppb) and cis-1,2-dichloroethylene (4 ppb) while the residential well test results indicated tetrachloroethylene at a concentration of 33 ppb. The contaminated shallow wells were replaced with deeper wells.

A cement holding tank (40,000 gallon capacity) located behind the laundromat was found leaking. It is suspected the the walls of the tank are cracked. The discharge flowing into the tank was sampled and the sample test indicated PERC (500 ppb).

Area soils consist of sand and gravel about 34 to 54 feet below grade overlying clayey sand greater than 15 feet in thickness. Approximately 216 people are served by wells in the 90 degree are of the 1/2 mile radius while a total population of approximately 850 people reside within the 1/2 mile radius. No school or hospital is located within 1/2 mile. Mio Dam Pond of the Au Sable River is located just beyond the 1/2 mile radius.

SITE DESCRIPTION

Auto Specialties
643 Graves Street
St. Joseph, Berrien Co., 49085

Site Number 6

RSAS Screen: 42   RSAS Score: 1404   SAS Screen: 10   SAS Score: 847

Auto Specialities is a 125 acre site which has been in operation since 1917. From 1917-1981, the facility operated as a malleable iron foundry. From 1922-1985, the plant producted of jacks involved metal fabrication, and auto parts washing and painting. Operations from 1938-present include mixing, forming and bonding of asbestos for brakes and clutches. The facility has had numerous above and below ground oil tanks and has utilized a settling pond and a 30 acre fill area in the course of operations.

A RI/FS undertaken by Whirlpool Corporation has identified five significant areas of contamination: a 30 acre fill area with EP toxic foundry sands and some solvents, fuel oil tanks (free product on the water table in one area), a settling pond, contaminated soils area and a utility area with PCB contamination. It appears that there is moderate to low level metals and oil contamination of soils throughout the plant area. The plant building also contains asbestos and the RI acknowledges that some of the asbestos contamination in the Paw Paw River may be coming from the plant.

The facility lies within 1000 feet of the Paw Paw River to the West and the St. Joseph River to the South. Lake Michigan is about 600 feet to the west. The fill area is on the banks of the Paw Paw River.

The city is on municipal water supply and there are no private wells within a one-half mile radius. Water is supplied by a Lake Michigan intake about one-half mile off shore. The water works building is 2500 feet to the NW on the lake shore. No schools or hospitals are located within the 1/2 mile radius. Approximately 532 people live within the 1/2 mile radius, most of the land use being commercial/industrial in nature. Several parks and public beaches are within the 1/2 mile radius. The entire flow area of the Paw Paw River within the 1/2 mile radius is classified as wetland.

SITE DESCRIPTION

Story Chemical Company
Ott-Cordova
500 Agard Road, P.O. Box 5150
Muskegon, Muskegon Co., 49445

Site Number 7

RSAS Screen: 43   RSAS Score: 2028   SAS Screen: 10   SAS Score: 1058

The Ott-Story Cordova Chemical Company facility is located in Delton Township, north of the City of Muskegon. Various chemical companies have occupied the site since 1957. Water supplies were obtained from on-site wells and wastewater was disposed of via seepage lagoons. The facility was abandoned in 1977 by the then owner, Story Chemical Company.

Waste handling practices at the site from 1957 to 1977 resulted in extensive groundwater contamination, contaminated soils, and unprotected tanks of phosgens gas. Approximately 1.2 billion gallons of groundwater contaminated with organic chemicals including 16 priority pollutants is moving into Little Bear Creek and its tributary, causing serious degradation of one mile of stream.

The most recent study indicated biotic degradation but low contaminant levels in the Creek. The West Michigan Shoreline Regional Development Commission Study of 1982, showed 100 ppb benzene, 9 ppb chlorobenzene, 12 ppb chloroform, 35 ppb 1,1-dichloroethane, 7,200 ppb 1,2-dichloroethane, 38 ppb 1,1-dichloroethene, 69 ppb methylene chloride, 110 ppb toluene, 8 ppb t-1,2-dichloroethylene, 9 ppb 1,1,1-trichloroethane, 2,200 ppb vinyl chloride, 16 ppb 2-chlorophenol and 6 ppb phenol in the water column. Sediments showed 300 ppb acetone, 3 ppb benzene, 1 ppb 1,1-dichloroethane, 5 ppb 1,2-dichloroethane, 6 ppb methylene chloride and 15 ppb toluene.

Levels of benzene and 1,2-dichloroethane have been found in the air in the breathing zone along Little Bear Creek and at the Rive Road Bridge.

The population in the area is approximately 1,348 people but no schools or hospitals are within the 1/2 mile radius. Soils are 60-89 feet of sand overlying 100-170 feet of alternating clay and sand layers. Total clay thickness is 60-110 feet in three layers.

An alternative municipal water supply for homes with contaminated wells has been provided from a source outside the 1/2 mile radius. The plant property is adequately fenced with Cordova Chemical controlling access.

SITE DESCRIPTION

G & H Landfill Site Number 8
23 Mile Rd., Shelby Twp.
Utica, Macomb Co.

RSAS Screen: 43 RSAS Score: 1991 SAS Screen: 10 SAS Score: 1016

From the late 1950's to 1966, millions of gallons of industrial waste liquids including oils, solvents, and process sludges, were disposed of at this now closed landfill. Liquid wastes were dumped in pits and lagoons on the 80 acre site. A Consent Order was entered into in 1967 requiring the company to cease disposal of all liquid wastes. The settlement, however, did not require the company to clean up the wastes already dumped at the site. The site operated as a refuse landfill from 1967 until it closed in 1974. With unauthorized dumping until 1986.

In 1986, the U.S. EPA performed soil borings and installed additional groundwater monitor wells. Two test pits were dug in areas where oil ponds once existed. Investigators found and took samples of oil-soaked soils and sludge. Eight test pits were dug where buried drums were suspected. Buried drums were found in two of the test pit areas.

Private well samples taken from six homes along Parsons Road and from homes on Ryan Rd. did not show any detectable levels of contaminants. The wells of several businesses on the west side of Ryan Road continue to show the presence of some contaminants, but the concentrations of contaminants have been generally declining since 1983 when contaminants were first discovered. Owners of these wells have been advised not to use the wells.

In the Spring of 1986, the U.S. EPA conducted an emergency removal of PCB contaminated oils seeping from the base of the landfill. These oils have been contained and collected on site pending appropriate disposal.

The Clinton River is within 1/4 mile of the site and includes extensive wetlands in its flood plain. There are 330 homes within the 1/2 mile radius and a population of approximately 1328 people. No schools or hospitals are within the 1/2 mile radius.

An interceptor trench has been installed between the lagoons and the Clinton River to contain oil seeping from the site. Oil seeps contain 500 ppm PCBs, benzene, toluene, DCA, DCB, TCB, ethylbenzene, and xylene.

Soils are sandy loam with layers of silt to a depth of at least 10 feet. The water table is at a depth of 8 feet on site.

SITE DESCRIPTION

Abandoned Tank Farm Lower Harbor
Front and Whetstone Streets
Marquette, Marquette Co.

Site Number 9

RSAS Screen: 34 RSAS Score: 1771 SAS Screen: 9 SAS Score: 730

The site, located in the harbor basin along Lake Superior, includes two tank farms and three ship unloading facilities. The north tank farm, consisting of four tanks, was in use from the 1940s until about 1978. From then, the north tank farm was used for caustic soda storage until March, 1986, when a caustic soda spill of approximately 200,000 gallons occurred. Some soil excavation and removal occurred but it is estimated about 1/3 of the material was lost. The south tank farm, consisting of three tanks, was built in the 1920s and used until the mid 1970s. Until 1985, the tanks were used to store cracked #4 oil. Approximately three to five inches of oil may remain in the tanks. Petroleum contamination was observed in on-site soil borings using an OVA. Benzene, toluene, and xylene and #2 fuel oil were detected in a monitoring well at 9700, 2000, 5600, and 8000 ug/l respectively.

The general soil profile consists of 7.5 feet of silty sand fill overlying up to 9 feet of coarse sand aluvium. The water table at the site ranges from 4.5 to 10 feet below grade. Due to proximity to the lake, fluctuations of Lake Superior water level may influence the water table level at the site.

The Marquette municipal water system is supplied by a surface water intake in Lake Superior approximately 1 1/4 miles from the tank farm (approximately 3/4 mile off shore). There are no known groundwater wells within the 1/2 mile radius of the facility. The Marquette population within 1/2 mile is 11,644 people. Two schools and one hospital are within the 1/2 mile radius with a public boat launch and two marinas within two miles.

SITE DESCRIPTION

Douglas Components
141 Railroad Street
Bronson, Branch Co.

Site Number 10

RSAS Screen: 24 RSAS Score: 809 SAS Screen: 08 SAS Score: 504

Douglas Components Corporation manufactures automobile and machinery parts. Since 1978, a 4,000 gallon underground concrete tank has been used to store waste cutting oil on the property. Lab results show that the oil contains solvents, including methanol, ethanol, ethylene chloride and ethyl benzene. In past years TCE was used by the company. An inspection of the property revealed that the tank and surrounding concrete slab has sunk into the ground. The tank is leaking.

Soils in the area are predominantly sand down to 18 feet, gravel down to 30 feet, followed by sand and gravel. Water is found approximately 7 feet below the surface. Groundwater underneath the site was found to contain a high level of grease and oil (up to 15,000 mg/l). 1,1,1-trichloroethane (6500 mg/l), chloromethane (0.56 mg/l), 1,2-dichloroethane (0.29 mg/l), 1,1-dichloroethylene (54 mg/l), ethylbenzene (58 mg/l), methylene chloride (180 mg/l), toluene (46 mg/l) and xylene 230 mg/l) were measured in monitoring wells.

A soil vapor survey indicates high levels of volatiles including 15,000 mg/kg toluene 20 feet from the buried tank.

Ground water flow is believed to be to the north northwest. There are several private wells within a few hundred feet from the area of groundwater contamination, lateral to ground water flow. These wells are not contaminated.

Approximately 80 people live within the 1/2 mile radius but only 8 are within the 90 degree area of the ground water flow direction. No schools or hospitals are located within the 1/2 mile radius. An unnamed drain with continual water flow is located 1200 feet north of the site. This is tributary to Swan Creek which is surrounded by extensive wetlands.

SITE DESCRIPTION

Old Koppers Site/Hersey River Site Number 11
E. Lincoln Street
Reed City, Osceola, Michigan 49677

RSAS Screen: 35 RSAS Score: 1836 SAS Screen: 10 SAS Score: 734

This site consists of the present location of the Reed City Wastewater Treatment Plant, formerly a Koppers Company wood treating plant, and a two mile stretch of contaminated sediments in the Hersey River between Reed City and the Village of Hersey. The Michigan Wood Preserving Company originally built and operated a wood treating facility at this site between 1913 and 1935. Koppers Company operated the plant until it closed in 1949.

There are five areas at the site where contaminants are suspected of having entered the soil, ground and surface waters. Two spills of 15,000-18,000 gallons from creosote storage tanks. Two concrete dip tanks, leaked badly, released unknown quantities of creosote into the ground. Steel tanks were later inserted in these dip tanks. Freshly treated lumber was allowed to drip onto the ground in the vicinity of the present City Garage. Hardened tar and oil were also observed on the ground surface in this area. The lower terrace along the Hersey River appeared to be a disposal area which had oily sludges running into it. The southeast area of the plant site appeared to be an area of extensive fill of unknown materials.

An estimated 6,724,080 kilograms of contaminated sediments are present in a two mile stretch of the Hersey River as well as an unnamed creek immediately south of the site which flows into the Hersey River. Phenanthrene, chrysene and benz(a)pyrene are present in the sediments in levels as high as hundreds of parts per million. Globules of creosote leachate have also been observed on the river and creek bottoms containing these polynuclear aromatic hydrocarbons in percentage (parts per hundred) concentrations. There is a fish consumption advisory for this stretch of the Hersey River.

Drinking water is supplied by a municipal system and no wells are known to exist within the 1/2 mile radius. No schools or hospitals are within the 1/2 mile radius. Soils consist of silty sand for 5 to 8 feet, a 3 to 5 float silty clay horizon, and greater than 20 feet of sand. The water table ranges from 3 feet to 8 feet below grade.

SITE DESCRIPTION

Pool Company Area Site Number 12
Seeley Rd., 1.5 miles north of Kalkaska
Kalkaska Co. 49646

RSAS Screen: 24 RSAS Score: 908 SAS Screen: 06 SAS Score: 243

The Pool Company area site is approximately 5 acres in size. There has been chloride contamination in the Pool Co. well and the Smith residential well was contaminated but has been replaced. Suspected sources of the contamination include: the Pool Co. brine pit which is lined, although monitoring wells have shown leakage in the past; downgradient, the Adams Trucking facility, which houses oil field brine in storage tanks and a loading/unloading ramp (presumably clay lined) from which overflows and spills have occurred; the Wolverine Oil Well Service also operated a brine pit in the area about 10 years ago.

Chloride levels of 600 ppb were detected in the smith well before it was replaced. An unnamed drain, tributary to the Rapid River (1 1/2 miles from the site) flows within 1/3 mile of the site. There are extensive wetlands along the river. The site is adjacent to the Au Sable State Forest and only two homes are located within a 1/2 mile radius. No schools or hospitals are located in the area.

Soils consist entirely of sand or sand and gravel to a depth of at least 94 feet below grade. The static water level is located approximately 60 feet below grade.

SITE DESCRIPTION

Boardman Lake Canning Co. Site Number 13
3710 Cass Rd.
Traverse City, Grand Traverse Co.

RSAS Screen: 26 RSAS Score: 501 SAS Screen: 3 SAS Score: 3893

The Boardman lake Canning Company site is situated on the west side of Boardman Lake, an impoundment on the Boardmen River. Boardman Lake Company (Traverse City Canning Company) has gone out of business and the property has been bought by Chef Pierre Inc. The company formerly discharged dilute cherry brine, approximately 150 ppm chloride, from the canning process into the southwest end of Boardman Lake. The brine was also used for sprinkle irrigation of the lawn at the plant.

An orange precipitate (primarily ferrous iron) was formed on the rocks and sediments in Boardman Lake. The precipitate corresponded to the company's property lines and the time of the irrigation. It is believed that the brine used to irrigate the lawn leached the iron out of the soil, resulting in the formation of the precipitate when the groundwater discharged into the lake.

Groundwater flow is assumed to be toward Boardman Lake. Drinking water is supplied by a municipal system whose source is a surface water intake in the East Bay of Grand Traverse Bay, about four mile distant. Soils are 60 feet of sand and gravel over greater than 188 feet of sandy clay. No schools or hospitals are within the 1/2 mile radius. Population is approximately 5,500 people within the 1/2 mile radius. A significant coldwater fishery exists in the river with a significant bass and walleye fishery in the lake.

SITE DESCRIPTION

Du-Laur Products, Inc.
211 Sherman
Vassar, Tuscola Co.

Site Number 14

RSAS Screen: 28 RSAS Score: 421 SAS Screen: 05 SAS Score: 563

Du-Laur Products manufactures and paints a variety of small machine parts and novelty items. Waste paings and solvents had been left in uncovered barrels outdoors, on-site without secondary containment. In addition these materials were also disposed in a ditch directly behind the building. Many spills of the waste paints and solvents have also occurred. The waste management practice was to paint and solvent residues on the ground and dig up the solids for disposal in a landfill after the liquids had evaporated or seeped into the soil. Du-Laur claims to have cleaned up much of the contaminated soils. They now store all critical materials in a covered dyked storage facility.

The Cass River lies within 1/8 mile of the facility but no significant wetlands are in the immediate area. The river acts as an aquaclude to ground water flow to the north west. The city of Vassar is sewed by a municipal supply system with two wells within 1/2 mile of the site on the south wet side of the river. Approximately 716 people are sewed by this system. Approximately 1200 people are within the overall 1/2 mile radius. No schools or hospitals are located within the 1/2 mile radius.

Soils consist of 18 feet of sand over 16 feet of clay and 40 feet of hard paint. The aquifer consists of 49 feet of sandstone and at least 135 feet of shale.

SITE DESCRIPTION

Harsen's Island Barrel Dump
3601 Rattray Lane
Harsens Island, St. Clair Co.

Site Number 15

RSAS Screen: 21 RSAS Score: 570 SAS Screen: 6 SAS Score: 517

Harsen's Island Barrel Dump is a site where approximately 160 barrels containing liquid RCRA hazardous paint and resin wastes were dumped on the 67 acre property of Mr. Jack Rattray in the early 1970s. Selected barrels were sampled and found to contain EP toxic wastes fro chromium (up to 6.7 ppm), nickel (up to 81 ppb), lead (up to 63.9 ppm) and zinc (up to 2,500 ppm). The property is crossed by Harsen's Drain and a marshy slough connected to the North Channel and South Channel, respectively, of the St. Clair River. Many of the barrels were dumped directly into the marsh. Downstream of the north channel from its confluence with Harsen's Drain, seventy homes use surface water as their sole source of drinking water. In addition, 14 homes within a one-half mile radius of the site use groundwater as their drinking water source. No public water supply system is available.

Soils are peaty loam ranging from seven to 12 feet in depth overlying peaty sands with approximately 35% silts and clays. Water table is at five feet below grade with no discrete clay layers present. Potable wells are completed between 20 and 30 feet below grade.

A subdivision consisting of 80 homes is located on canals from Harsen's Drain near the North Channel. Three public access points and a marina are also located on the north channel within two miles of the confluence of Harsen's Drains and the North Channel. Extensive hunting and fishing activities occur in the marshes and nearby river.

SITE DESCRIPTION

Packaging Corp of America
Steinberg Road
Manistee, Manistee Co.

Site Number 16

RSAS Screen: 37   RSAS Score: 1643   SAS Screen: 6   SAS Score: 482

In 1947, ABB Co. bought an existing pulp mill which used northern softwoods to produce corrugated medium for boxes. In 1949, the mill changed from the kraft process to the NSSC process (sodium sulfite and sodium carbonate). Black liquor was discharged to Lake Manistee until 1951 when the WRC required construction of seepage lagoons. A kraft mill was built in 1957 and the waste streams from both plants were sent through an evaporator and water recovery system to reduce the volume of waste going to the lagoons. A clarifier was also installed in 1958 to remove cellulose and solids from the wastewater discharge going to Lake Michigan. The clarifier sludge was also placed in the lagoons. In 1959 ABB Co merged with two other companies to form Packaging Corporation of America (PCA). A secondary treatment plant was built in 1972 and lagooning was stopped. 81 to 598 million gallons of wastewater were lagooned per year during lagoon operation. Between 1970 and 1976 the lagoons were pumped out to seepage areas and are now empty. The lagoons cover 61 acres and the seepage area covers 45 acres. In 1956 a brine well 2,200 feet from the lagoons was found to be contaminated by black liquor. A plume of high BOD, color, chloride, sodium, arsenic, lead, phenols, and benzoic acid has been found to be discharging to Lake Manistee 2,500 ft. from the lagoons.

The water table is found approximately 70 feet below grade throughout the site and varies from 40 to 200 feet in thickness. Soil throughout this zone consist of permeable sand and gravel. Groundwater flow is from west to east. Commercial and private wells are completed in this zone. Twelve homes within the 1/2 mile radius have private wells and a public system supply well serves an additional 213 people. There are no public access points or beach access points within six miles but more than 800 people have shoreline access from private homes. No schools or hospitals are located within 1/2 mile of the site and no wetlands are found in the immediate vicinity.

SITE DESCRIPTION

Belfer Drum and Barrel
4336 Hansen Ave
Wyoming, Kent Co.

Site Number 17

RSAS Screen: 24   RSAS Score: 296   SAS Screen: 04   SAS Score: 260

This facility reclaims used metal drums. Their process involves burning the drums to clean out residuals and to strip off old paint. Melted residuals are put into a floor trough where water is added to prevent flaming. The liquid is recirculated and separated for reuse.

Site investigations revealed a 60′ x 40′ area contaminated with 150 ppm of PCB′s. Oil spills from drum bottoms is assumed to be the source. Belfer paved this area, reducing the direct contact hazard and the potential for leaching, but not addressing the release. There is still no indication that the soils have been removed and disposed of properly.

The company has a long standing nuisance problem in relation to its burning operation. They did install new equipment in 1978 and they appear to be in compliance with their most recent air pollution control permit which was issued in 1983.

Soils consist of two to three feet of clayey, sandy loam, 24 feet of medium sand overlying greater than 100 feet of clayey sand. Drinking water is provided by a municipal system with the water source being Lake Michigan, remote to the area. No schools or hospitals are within the 1/2 mile radius. Approximately 4000 people reside within 1/2 mile. U.S. 131 passes within 1/4 mile of the site and numerous commercial businesses are also in the area. No surface water body lied within the 1/2 mile radius and stormwater is collected in a combined sewer system so all stormwater is treated before released to the Grand River approximately 2 1/2 miles to the west.

SITE DESCRIPTION

Severance tool Industries Site Number 18
3790 Orange St.
Bridgeport, Saginaw Co.

RSAS Screen: 26 RSAS Score: 542 SAS Screen: 8 SAS Score: 441

Severance Tool is a tool and die manufacturer which occupies a six acre city block. The immediate plant area is three acres. An old 7000 gallon septic tank was used for storage of process waste for an unknown number of years. The tank was never drained and often overflowed. In 1986, liquids in the tank were sampled and 1,1,1 trichloroethane (1,730 ppb), 1,1 dichloroethane (5,180 ppb), trichloroethylene (3 ppb), barium (864 ppm), and chlorides (4,800 ppm) were detected. Contamination has spread to the septic tank drain field with significant levels of the above compounds as well as chromium (710 ppm) and lead (58 ppm) detected in borings. Access to the property is restricted by fencing.

Soils consist of one to two feet of clayey, silty, loam with three to five feet of sand overlying 24 to 30 feet of silty clay. The clay is wet and saturated two feet into the layer. The city is served by municipal water but the immediate area is not in the distribution network. Many of the wells are crock wells completed to 10 feet below grade because the clay layer is at least 105 feet thick over sandstone. The population is 978 people. The severance potable water supply well is crock well and serves approximately 180 employees. Two schools are located within the 1/2 mile radius but no hospitals. The Cass River is within 1/2 mile of the site but no significant wetlands are in the area.

SITE DESCRIPTION

Mt. Elliot Drum Site
Mr. Elliot Street
Detroit, Wayne Co.

Site Number 19

RSAS Screen: 20 RSAS Score: 268 SAS Screen: 04 SAS Score: 330

The Mt. Elliot Drum site is situated on a vacant lot across from 18677 Mt. Elliot Street, between 6 Mile and 7 Mile Roads in Detroit, Michigan. The vacant lot measures approximately 380 feet by 500 feet. Retail businesses and light industrial facilities are located along Mt. Elliot Street. Private residence surround this area, some as close as 200 feet from the affected area. Although fencing exists around most of the site, the alley and an open gate on Mt. Elliot Street provide unrestricted access to pedestrian or vehicular traffic.

Ownership of the property has yet to be determined. A drum recycling facility was once located on the lot, followed by a battery reclamation company which went out of business after a fire destroyed the facility. An investigation found 101 drums, of which 82 contained waste materials generated from an injection mold processing facility. Drum labels indicated the materials to be methylene chloride, trichlorofluoromethane, dipheyl methane diisocyante (MDI), and toluene diisocyanate (TDI). The drums were scattered about the site, several were leaking and many more were in poor condition. Approximately 25 percent of the lot was covered with metal filings waste, which did not appear to be associated with the abandoned drums. By November 2, 1986 the responsible party had removed all 101 drums and 20 cubic yards of soil.

Soils in the area consist of 2 to 8 feet of sand overlying 12 to 80 feet of hard pan and 9 to 68 feet of clay. The saturated zone is greater than 27 feet of sand. Drinking water is supplied by a municipal system with a surface water source remote from the site. The area residential population is approximately 4600 people. Three schools and four playgrounds are within the 1/2 mile radius but no hospitals are nearby. No surface water bodies are located within the 1/2 mile radius.

SITE DESCRIPTION

Ferrysburg Area Ground Water Contamination Site Number 20
Pine and Oak Streets
Ferrysburg, Ottawa Co.

RSAS Screen: 27 RSAS Score: 984 SAS Screen: 86 SAS Score: 780

Two commercial and three residential wells on Pine and Oak streets in central Ferrysburg were found to be contaminated in 1988. Two of the residences were found to contain 52 and 59 ppb tetrachloroethylene while the other wells were contaminated with 58 ppb 1,1,1 trichloroethane, 6 ppb dichloroethane, or 59 trichloroethylene. Aside from the first two wells, none of the wells contain the same contaminants. Studies are on going but no source(s) have been identified. The Ferrysburg area is served by a municipal suply system whose source is Lake Michigan. Three quarters of the town is within the 1/2 mile radius and 84 homes are still on private wells.

Soils consist of one to two feet of sandy loam overlying medium sand. None of the well logs reveal the presence of a clay confining layer. The used aquifer is the saturated sand with a water table ranging from four to 10 feet below grade. The Grand River is between 1/8 to 1/4 mile from the contaminated well area and Lake Michigan is approximately 1 3/4 miles west. A public access point is approximately 3/4 mile downstream with the mouth of the Grand River in Grand Haven being approximately 2 1/2 miles downstream. Extensive public beaches and private homes line the Lake Michigan shore.

Wetlands are in the Grand River flood plains near the contamination area. No schools or hospitals are located within the 1/2 mile radius but one of the contaminated wells belongs to the Post Office. Bottled water has been supplied to the homes and public water has been turned off at the Post Office.

SITE DESCRIPTION

Detroit Edison Dredged Spoils
Raisin River, Monroe Harbor
Monroe, Monroe Co.

Site Number 21

RSAS Screen: 29 RSAS Score: 1639 SAS Screen: 5 SAS Score: 796

Throughout the 1970s into the early 1980s (1971-1983) sediments from the lower harbor and ship turning basin in the Raisin River were dredged and pumped to a confined disposal facility on Detroit Edison property. Sediments were contained first in a oval train track area and later in an adjacent diked area. The diked area was part of a wetland before filling. Sediment samples revealed large quantities of PCBs (21,190kg), arsenic (21,485kg), chromium (2,196,037kg), lead (241,746kg), zinc (1,098,698kg), and copper (2,921,521kg) when calculated for the volume of sediment and observed concentrations. The in place Raisin River sediments still contain high concentrations of PCB, chromium, lead, and zinc. All four contaminants have been found in lagoons and surface soils on the Consolidated Packaging Corp property while significant concentrations of the metals have been found on the Ford Motor Co property. Both properties are adjacent to the Raisin River in the vicinity of the Detroit Edison property. Sediments were originally placed in direct contact with wetland surface water. Soils consist of peaty loam, saturated at depths ranging from six to 12 feet below grade.

Area drinking water is supplied by a public system with a source in Lake Erie 1/3 mile offshore about 1/8 mile north of the river mouth. Lake Erie is 3/4 mile downstream from the disposal site. Extensive wetlands remain on the Detroit Edison property and adjacent to the river. A marina and public access area are located near the river mouth. Regional population density served by the water system is 2615 people per square mile. No drinking water exposure is projected. No hospitals or schools are located within the 1/2 mile radius. Blowing dry dust and fines from the sediment drying areas has been observed. The air population at risk is 1,308 people.

SITE DESCRIPTION

East Columbia Road Ground Water Contamination Site Number 22
East Columbia Road
Battle Creek, Calhoun Co.

RSAS Screen: 30 RSAS Score: 919 SAS Screen: 12 SAS Score: 734

In August of 1987, seventeen private wells between Inn Road and Illinois Street on east Columbia Road were found to be contaminated. Various concentrations of cis-1,2-dichloroethylene (1-12 ppb), chloroform (3 ppb), 1,2-dichloroethane (1-7 ppb), benzene (1-15 ppb), and methyl tertiary butyl ether (2-8 ppb) were detected. In 1988, a trailer park well serving 110 people was also found to be contaminated. The source of contamination is unknown although a bulk oil facililty and service station is nearby. Studies are underway to determine the source of contamination. The homes and trailer park are being provided bottled water and the city water main is being extended to service the area.

The water table is found between 39 and 47 feet below grade and is in direct contact with bedrock, the Marshall sandstone which is the principal source of drinking water for the area. Overlying soils consist of sand and gravel with clay lenses limited in horizontal extent and ranging from 3 to 20 feet in thickness. Direction of ground water flow is unknown but is suspected to be generally south/southwest toward the Kalamazoo River approximately one-third mile distant. There is no surface water drinking water source in the area and use of the Kalamazoo River in the area is limited due to a lack of public access points nearby. Wetlands are found adjacent to the Kalamazoo River. No hospitals or schools are located within one-half mile of the contamination area.

SITE DESCRIPTION

Residential Wells, Village of Meredith   Site Number 23
North M-18
Gladwin, Clare Co.

RSAS Screen: 26   RSAS Score: 1026   SAS Screen: 04   SAS Score: 878

Charles Howey and Irma Weiss suspected their drinking water wells to be contaminated with components of gasoline in March 1985. Sampling revealed 2 ppb toluene in the Weiss well and 26 ppb toluene along with 33 ppb xylene, 1120 ppb benzene, 2 ppb ethylene dibromide and 38 ppb dichlorethane in the Howey well. The potential source of these hydrocarbons was considered to be the sportsman's Paradise underground gasoline storage tank which is directly north of the Weiss well. On investigation, the storage tank tested "tight". Two other wells in the area (Prentice well and Clements well) showed 1 and 3 ppb respectively of tetrachloroethylene. To date, no "PRP" has been identified and all four previously contaminated wells have been replaced with deeper, protected wells through Act 307 emergency replacements.

Extensive wetlands and the middle branch of the Cedar River are located in the immediate area of the village. No surface water sampling has been conducted. Because the village is surrounded by wetlands, groundwater flow direction cannot be estimated. Private drinking water wells serve 256 people within the 1/2 mile radius. Soils are 12 to 14 feet of sand overlying 2 to 18 feet of clay. The aquifer is greater than 43 feet of sand and gravel.

SITE DESCRIPTION

Selfridge ANG Base
Mt. Clemens, Macomb Co.

Site Number 24

RSAS Screen: 31 RSAS Score: 1661 SAS Screen: 9 SAS Score: 891

Selfridge ANGB is situated on the western shore of Lake St. Clair, 0.5 miles to the east of Mount Clemens, Michigan. The Base has been active since 1922 operating under the Army, Air Force, and Air National Guard Command. Selfridge Field began with the leasing of 640 acres in 1917. Considerable expansion of the base occurred during World War II, with the Base reaching its present size of 3,727 acres. Most of the potentially hazardous wastes are generated by the routine maintenance of aircraft and ground vehicles, with lesser amounts generated by grounds maintenance activities. Seven areas of the base have been identified as problem sites. The site score has been based on all seven areas.

Area No. 1, Southwest Sanitary Landfill is located in the southwest corner of the base. The 40 acre site operated from 1970 to 1978 under Michigan Public Act 87, for the disposal of approximately 5,900 tons per year of residential and industrial waste. Typical wastes disposed of at this site included residential wastes, demolition materials, solvents such as trichloroethylene, carbon tetrachloride, and methyl ethyl ketone, paint strippers and thinners, and waste oils. A large number of drummed waste paints and solvents are also thought to be buried at this location.

Area No. 2, the Fire Training Area 2 is located in the southwest quadrant of the Base, north of the Southwest Landfill and west of the C Taxiway. Selfridge ANGB fire department personnel have used this pit since 1968 to conduct fire training exercises. Historically, an average of 8 to 12 training fires have been conducted there each year. During a training exercise, 350 to 500 gallons of JP-4 fuel is ignited and extinguished using water aqueous film forming foam (AFFF). Fire department personnel estimate that approximately 75% of fuel is consumed per event.

Area No. 3, Fire Training Area 1 was located to the north of Fire Training Area 2, near Building 567 in an unlined gravel pit and was used from 1952 until 1967. Waste flammables (i.e., JP-4, solvents, strippers, and thinners) were stored in drums between fire training exercises.

Area No. 4, West Ramp fuel spill area is located in the northwest section of the Base, adjacent to the west of the taxi-way. Two fuel spills have occurred at this site involving over 3,000 gallons of JP-4. Remedial clean up activities were attempted, however, the bulk of the fuel drained off of the ramp. Base personnel have reported a strong fuel odor in this area during extensive wet periods.

Area No. 5, Tucker Creek Landfill a natural depression on the east side of the Base commonly called Tucker Creek, was used for disposal of waste materials from 1930 to 1955. Refuse was burned and buried here. Demolition materials, residential refuse, and industrial waste materials such as carbon tetrachloride and trichloroethylene were disposed of in this area.

Area No. 6, the Northwest Landfill is located in the northwest corner of the Base. From 1955 to 1975, this site was used for the landfilling of waste products. Originally, this site was a natural sand pit from which the sand was excavated completely, down to blue clay, for the construction of the runways. Demolition materials were placed on the bottom of the pit followed by landfilling of residential and industrial waste. This site contains industrial waste products such as solvents, paint thinners, paint strippers, waste oils fuels and 150 gallons of tetraethyl lead.

Area No. 7, the East Ramp is located in the southern part of the containment area, near the eastern boundary of the Base. 3,000 gallons of JP-4 was spilled in this location. Remedial cleanup activities were attempted, however the bulk of the spill drained off of the East Ramp. Base personnel report a strong petroleum spirits aroma that appears during extensive wet periods in the vicinity of the East Ramp.

The residences near the base are serviced by a municipal water supply system. The base is adjacent to both the Clinton River and Lake St. Clair with wetlands along the shore.

Six homes west of the base are on private wells. The potential air exposure population is 3560 people.

SITE DESCRIPTION

Herman Radio Tower Site Number 25
Section 1, L'Anse Twp
Herman, Baraga Co.

RSAS Screen: 17 RSAS Score: 984 SAS Screen: 5 SAS Score: 573

This radio tower and microwave tower complex is owned by the Department of Natural Resources. A 350 gallon petroleum underground storage tank was removed in 1988 after it was found to be leaking. Fifteen cubic yards of contaminated soil were removed to within two feet of the service building. Contamination extends under the building but does not emerge from underneath the opposite side, approximately 15 feet distant. The tower facility is on top of a large hill which stands at an elevation of 560 feet A.S.L. over a surrounding area generally 510 to 530 feet A.S.L. Igneous rock outcrops are common near the tower area with soil thicknesses ranging up to four to seven feet. The tank was located on the uphill side of the building in four feet of soil, the downhill side being about seven feet deep. Soils consist of coarse sand and gravel.

The nearest well is 1/4 mile distant from the site. Twenty eight homes within the 1/2 mile radius use private wells as their drinking water supply. The static water level ranges from six to 20 feet below grade. Herman Creek is located 3/8 mile to the southwest and is not associated with any wetlands. No schools or hospitals are found within the 1/2 mile radius.

A slurry wall is being constructed on the uphill slope with a purge collection system on the down slope side of the building. The building perimeter enclosing the contaminated soils has been fenced.

SITE DESCRIPTION

Trading Post
300 Michigan Ave. (M-37)
Baldwin, Lake Co.

Site Number 26

RSAS Screen: 29 RSAS Score: 1926 SAS Screen: 12 SAS Score: 740

The Trading Post is a convenience store/gas station located approximately 500 feet north of the M-37 bridge over the Baldwin River in Baldwin. Five underground storage tanks were originally located on-site. Apparently two of the tanks leaked and were later removed. A 20′ by 20′ area of soils around the tanks was contaminated and floating product was observed on the groundwater surface. These contaminated soils were put back in the hole following the excavation of the tanks. No removal of the contaminated soils has occurred, nor have any monitor wells been installed.

Sampling of area residential wells detected 3 ppb of 1,1-dichloroethane in the Dostal residential well, 292 Riverbed Lane.

Forty nine homes within the 1/2 mile radius have private wells. The rest of the area is served by a municipal system. Area soils are 34 to 56 feet of sand and gravel overlying 4 to 15 feet of clay. The aquifer is greater than 147 feet of medium to fine sand with scattered lenses of sandy clay. The Baldwin River is a trout stream with shore wetlands. A public access site is located within the 1/2 mile radius.

SITE DESCRIPTION

US 41 Birch Creek
US 41
Menominee, Menominee Co.

Site Number 27

RSAS Screen: 24   RSAS Score: 1748   SAS Screen: 10   SAS Score: 398

Contamination typical of gasoline was detected in four residential wells along US 41 approximately 1 1/2 miles south of Birch Run in 1987. Concentrations of benzene (462 ppb), toluene (1144 ppb), xylene (1769 ppb) and methyl tert butyl ether (60 ppb) were found. The contaminated wells have been deepened and sealed from above. No underground tanks (commercial or private) were found in the area and it is believed that the contamination probably is the result of a one-time spill. No record of a tank truck spill in the area has been discovered. Because of the high concentrations, the large volume spill criteria of the O'Dell's evaluation method are triggered.

Soils consist of two to six feet of sand and gravel overlying 20 to 29 feet of clay and stone. The aquifer consists of greater than 30 feet of limestone ranging from 31 to 35 feet below grade. All wells are completed in the limestone. Groundwater flow direction is not known but is probably toward Lake Michigan 1 1/2 miles to the south east. Thirty nine homes are located within 1/2 mile of the contamination area, most of them to the east and south east.

Extensive wetlands fill almost the entire north west quadrant of the 1/2 mile radius of the site. They also extend into the north east quadrant. No other surface water bodies, including creeks or drainage ditches are with the 1/2 mile radius. No schools or hospitals are found within the 1/2 mile radius.

SITE DESCRIPTION

O'Dell's Gras City
3260 Eastern SE
Grand Rapids, Kent Co.

Site Number 28

RSAS Screen: 29 RSAS Score: 1675 SAS Screen: 8 SAS Score: 510

O'Dell's Gas City is a large volume gas station with no automotive service facility. Contamination investigations at this facility provided the basis for development of the O'Dell's scoring method. Leaded and unleaded gasoline tanks were found to be leaking resulting in extensive (horizontal and vertical) soil contamination. Original estimates of fuel loss were one tank volume (22,500 gal.) due to rupture of a tank seam. This was later reduced to 2,000 gallons. Monitoring wells showed ground water contamination of lead of (330 ug/l), benzene (1,800 ug/l), toluene (2,700 ug/l) and xylene (200 ug/l). One nearby private well was contaminated and placed on the city water supply system. District Staff believed that a large amount of fuel entered the storm sewer and was removed from the area.

Soils consist of fine yellow sand four to 10 feet thick overlying 12 to 18 feet of hardpan limestone. The aquifer consists of greater than five feet of coarse sand under the limestone. Six private wells remain, completed in the coarse sand.

Plaster Creek passes within 1/3 mile north of the site and may have received gasoline from storm sewer discharge. No public access points or fishing uses are identified for the creek but children from many nearby subdivisions play in it. Only small fringe flood plain wetlands are found along the creek. One school lies right at the 1/2 mile radius.

SITE DESCRIPTION

Thomas Solvents Rawsonville Site Number 29
McKean Road
Rawsonville, Washtenaw Co.

RSAS Screen: 39 RSAS Score: 1771 SAS Screen: 9 SAS Score: 837

Thomas Solvent Rawsonville is one of three locations owned by this company that have had extensive releases of solvents. The company is a solvent recycling firm which collects industrial solvents and stores them in above ground and underground tanks with no secondary containment or monitoring. Losses are believed to be due to fill pipe spills as well as tank leakage. Extensive areas of surface soil contamination exist (21,7600 ft^2). Soil concentrations are: 3,057 ppb, 1,1,1 trichloroethane; 5,433 ppb, trichloroethylene ; 4,200 ppb tetrachloroethylene; 2,000 ppb, benzene; 1,966 ppm, toluene; 15,000 ppb, ethylbenzene; and 36,000 ppb xylene. Strong odors were observed on the site. Ground water concentrations in on-site monitoring wells are: 500 ppb, trichloroethylene; 100 ppb, benzene; 10 ppm, toluene; and 50 ppb, xylene. Concentrations of toluene (100 ppb) and benzene (3 ppb) have been detected in a drain which discharges to the Huron River.

The Huron River is 1/3 mile away and used extensively for recreation and fishing. Bellevue Lake is formed by damming the river three miles downstream and several parks and public access points line its shores. No potable surface water intakes are located downstream. Three homes within the 1/2 mile radius were found to be on private wells. Soils are silty sand four to ten feet in thickness overlying approximately 35 feet of clayey sand. No continued clay layers are found in the area. The site has been fenced although no schools or hospitals are located within the 1/2 mile radius.

SITE DESCRIPTION

Thompson Spill
US 2
Thompson, Schoolcraft Co.

Site Number 30

RSAS Screen: 31 RSAS Score: 1754 SAS Screen: 11 SAS Score: 826

In October, 1984 a fuel transport vehicle overturned resulting in a spill of 1,000 gallons of diesel fuel, 4,000 gallons of leaded gasoline, and 3,600 gallons of unleaded gasoline. Recovery efforts (pure product collection and 1,710 cubic yards of soil excavation) removed approximately 3,000 gallons. Xylene (2 ppb) was detected in residential well 1/3 mile south west of the spill area in 1987. No other efforts of recovery or plume location/control are planned. Soils consist of two to 12 feet of silty fine to coarse sand overlying one to five feet of sandy uncontinuous clay. A three to five foot layer of gravel overlies the limestone aquifer, at least 30 feet thick.

Thompson Creek passes within 1/3 mile of the spill site to the northeast and Johnson Creek lies 1/2 mile to the south. Lake Michigan is 3/8 mile due east of the spill area. Coastal dune wetlands fringe the lake and extensive cedar, spruce, shrub wetlands lie 1/4 mile to the northeast. The Thompson Fish Hatchery lies 3/8 mile due north and the Thompson DNR Field Office is 1/4 mile to the north. No schools or hospitals are within the 1/2 mile radius but 42 homes lie within the 1/2 mile radius, most of them between the spill area and Lake Michigan. One public access point is within the 1/2 mile radius on Lake Michigan with numerous paths to the beach from Thompson and Highway US 2.

SITE DESCRIPTION

Dial Trucking
14015 Haggerty Road
Plymouth, Wayne Co.

Site Number 31

RSAS Screen: 29 RSAS Score: 569 SAS Screen: 3 SAS Score: 530

The Dial Trucking site is a 26 acre, type II landfill and a solid waste transfer facility located in Plymouth Township. The area is fenced on 3 sides with the west border being Sly Creek. Since the site opened as a licensed landfill and transfer facility in the 1960's it has accepted mixed municipal and industrial waste (non-ferrous metals) until its closure in 1971 under Act 87.

Leachate is draining into Sly Creek, which flows into the Middle River Rouge within 1/3 mile of the site. No wetlands are found in the area. Shoreline access accommodates approximately 600 homes. The potential air exposure population is approximately 1280 people.

Plymouth Township utilizes a municipal water supply and no wells exist on site. Five homes south west of the fill within the 1/2 mile radius are on private wells. Area soils consist of 4 to 19 feet of sand and gravel overlying 8 to 65 feet of clay. A 20 to 48 feet hard pan layer is underneath the clay. The aquifer is 47 feet of sand and gravel overlying shale.

SITE DESCRIPTION

Liquid Disposal Incorporated (LDI) Site Number 32
Hamlin and Ryan Roads
Utica, Macomb Co.

RSAS Screen: 40 RSAS Score: 750 SAS Screen: 9 SAS Score: 667

In 1983 two employees were killed when they inadvertently mixed wastes from two storage vats which reacted and produced toxic gas. The company was an industrial liquid waste hauler and incinerator with some solvent recovery capabilities. At the time of State enforced closure in 1983, there were 8 acres of contaminated soils, 1419 drums of various solvent, paint and other liquid chemical wastes, a 5,500 cubic meter lagoon, a 1630 cubic meter incinerator pit surrounding the incinerator which was flooded with liquid waste, and eight buried tanks containing plating wastes high in heavy metal concentrations. One tank also contained PCBs. Since that time, the State has removed the drums and tanks, drained the lagoon and incinerator pit removing sludges in the bottoms. Only part of the lagoon bottom and about 6.8 acres of contaminated soil remain as well as an undefined extent groundwater plume. Soil contamination includes unquantified amounts of trichloroethylene, toluene, tetrachloroethylene, chloroform, 1,2 dichloroethane, phenols, phthalates, ether, ethylbenzene, copper, chromium, zinc, lead and chlorine. The site is fenced to control access but low level chemical specific odors are still present.

Twenty homes in the area are known to be on private wells but only seven are downgradient in the direction of groundwater flow. Flow is through the Rochester-Utica State Recreation Area to the Clinton River approximately 1/4 mile distant. Extensive wetlands are within the river flood plain. There are two public access points to the river which is used for small boats and several picnic areas are within two miles downstream. Sport fishing is also practiced in the river. Soils consists of six to 20 feet of gravely clay, zero to 40 feet of clay, and greater than 10 feet of sand and gravel. Wells are completed beneath the clay layer which thins out away from the river and is not continuous. No schools or hospitals are located within the 1/2 mile radius.

SITE DESCRIPTION

Poseyville Landfill
Poseyville Road
Midland Township, Midland Co.

Site Number 33

RSAS Screen: 31 RSAS Score: 516 SAS Screen: 9 SAS Score: 683

The Poseyville Landfill is a closed landfill which is currently owned and operated by Dow Chemical U.S.A. There is a breakout in the wall of the landfill which probably occurred before Dow took ownership in 1955. Prior to this date, Poseyville was owned by the City of Midland.

The landfill is 4,000′ X 800′ (74 acres) and is situated at the Dow Corporate Boundary. Many homes in Midland Township are within 1/2 mile and the City of Midland is one mile away. The Tittabawassee River flows to the north and around to the east as close as 1/4 mile from the northeast corner of the landfill. No wetlands are in the ara.

The break in the landfill's wall has contaminated groundwater as far out as 1,000′ and probably beyond. Monitoring wells have confirmed the presence of bis ethylhexylphthate (110 ppb), dichloroethylene (62 ppb), nitrophenol (6 ppb), dichlorophenol (32 ppb) and dimethylphenol (9 ppb). There are currently four purge wells which Dow claims are containing the zone of influence.

Private wells serve 624 people within the 1/2 mile radius. Soils consist of 7 to 9 feet of sand overlying 2 to 9 feed of clay. The aquifer is greater than 99 feet of sand with occasional lenses of 2 to 5 feet of clay.

SITE DESCRIPTION

Menasha Corporation
320 North Farmer
Otsego, Allegan Co

Site Number 34

RSAS Screen: 21 RSAS Score: 713 SAS Screen: 7 SAS Score: 150

Menasha Corp is a paper mill which manufactures medium stock from recycled paper and some reduced pulp. It is located adjacent to the Kalamazoo River until 1985. Waste treatment was accomplished in a 12 acre series of lagoons constructed in the flood plain of the river. The lagoon bottoms were excavated below the water level of the river and were flooded with river water. The lagoons were unlined. New lined lagoons have been built in uplands north of 105th street and the Penn Central Railroad tracks approximately 1/4 mile from the river. No contamination problems are associated with the new lagoons. Trace levels of PCBs were discharged in the bulk storage area for paper to be recycled but these have been removed. The original lagoons contained substantial levels of sulfides, chlorides, phenols, chromium, cadmium, and lead in the sludges. These contaminants were also found in the ground water in monitoring wells placed between the lagoons and the river. The lagoons have been pumped, sludges excavated, and filled. Some contaminated sludge remains, however, and the contaminated groundwater has not been addressed.

There are 18 homes on private wells within the 1/2 mile radius adjacent to the lagoons to the east and on a lateral gradient. Because of mounding of water in the lagoons, ground water flow could be moving in that direction toward an unnamed creek and wetlands in a former oxbow of the river. The wetlands are also extensive both adjacent to the lagoons and downstream. Soils in the floodplain are mainly coarse sands and gravels. A layer of stony clay, six to 16 feet thick lies 27 feet below grade. It is not known whether this clay is continuous but it is deeper than the river bottom. The City of Otsego municipal system gets its water from shallow wells in the gravel in the river flood plain downstream from the mill. The water is essentially filtered river water.

There are four parks and two public access points on the river within two miles of the mill. Duck hunting occurs in the river wetlands and boating also occurs. There is a fish advisory for PCBs due to contamination from upstream but catch and release fishing still occurs. No schools or hospitals are located within the 1/2 mile radius.

SITE DESCRIPTION

Crystal Falls Twp. Disposal
Power Dam Road
Crystal Falls, Iron Co.

Site Number 35

RSAS Screen: 12 RSAS Score: 417 SAS Screen: 02 SAS Score: 280

Situated approximately one mile northwest of the City of Crystal Falls, 0.5 miles east of U.S. 141, on land owned by Inland Steel Company, this solid waste disposal site is operated by Crystal Falls Township. The site was licensed from 1976 until May 1982 when it was closed.

This 7.2 acre dump received refuse from the Townships of Crystal Falls, Hematite and Mastadon. Refuse deposited here includes household and commercial waste, construction and demolition debris, trees, and stumps. No known disposal of hazardous waste has occurred. Evidence of burning is also frequently encountered.

Wetlands form the eastern border of this disposal site. The Paint River, a cold water fishery, flows within 1/8 mile from this site.

Operated as an unlined disposal area, the refuse is not properly protected from underlying groundwater. Subsurface conditions generally consist of 30 to 97 feet of very permeable sands or sand and gravel with some clay lenses 17 to 32 feet thick. Clay is not found at all wells indicating discontinuous lenses. The bedrock is slate, 200 feet below grade, and is not considered to be a useable aquifer. Eight residential wells, situated in the permeable unconsolidated sand, are located between the dumping area and the Paint River.

SITE DESCRIPTION

Bates Township Dump
Bates - Gaastra Rd
Rogers Location, Iron Co

Site Number 36

RSAS Screen: 18 RSAS Score: 427 SAS Screen: 3 SAS Score: 300

Bates Township owns and operates an unlicensed open dump. The land parcel is 80 acres with approximately 40 acres being filled. The dump is situated in a wooded low area with wetlands on two sides and standing water on a third side. Refuse is dumped in unlined trenches six to seven feet deep which are covered with sand when the trenches are full. Daily cover is not applied and there is evidence of periodic burning of refuse. The dump accepts commercial and household refuse, demolition debris, trees and stumps. There is no evidence that industrial or hazardous waste disposal has occurred. Occasional drums have been observed during inspections but these have been empty. The dump is unfenced although road access is restricted by a gate.

The surrounding land is higher than the dump but this is less than 1/8 mile wide. The dump is surrounded by wetlands to the southeast, south, and west. Flow from the wetland is northwest to west in Baker Creek which loops around the dump in these wetlands. The creek passes within less that 1/8 mile of the dump and discharges to Ice Lake which discharges to the Iron River. Both the lake and river are used for recreation and fishing. Hunting and recreation occurs in the wetlands.

Seven homes on private wells are located within 1/2 mile of the dump. Soils consist of 70 to 89 feet of sand and gravel layers overlying 53 feet of hard pan. A seven foot clay layer overlies bedrock. The wells are completed 10 to 20 feet above the hard pan. No schools or hospitals are located within the 1/2 mile radius.

SITE DESCRIPTION

Former Rancour Property
Chestnut St and Slosson Ave
Reed City, Osceola Co.

Site Number 37

RSAS Screen: 34 RSAS Score: 1910 SAS Screen: 7 SAS Score: 868

This one acre property was the location of a small machine shop. The building was removed and excavations to build a bank discovered waste oil floating on the groundwater. Soil analysis revealed trichloroethylene (15,800 ppm), 1,2 dichloropropane (1,450 pm), benzene (268 ppm), styrene (975 ppm), xylene (353 ppm), trichloroethane (8 ppm), tetrachloroethylene (2 ppm), and lead (326 ppm). The PRP has refused to conduct remediation.

There are 20 homes within the 1/2 mile radius on private wells and a city well 300 feet away toward the Hersey River within the 1/2 mile radius serves 2,221 people. At the site, 5 feet of sand and gravel overlie two feet of clay. Water is perched on the clay. The unsaturated zone ranges from seven to 19 feet with two to 10 feet of silty sand and gravel over two to 12 feet of clay. The saturated zone consists of thicker than 18 feet of silty sand.

The mill pond of the Hersey River lies less than 1/8 mile to the north east. This area is a park and the river is used as a trout stream. A fish advisory is in effect two miles downstream due to the Old Koppers contamination site. The pond is mostly drained and it banks are a wet meadow wetland. Several hundred homes, many with docks, line the river. There is one school but no hospital within the 1/2 mile radius.

SITE DESCRIPTION

Tri City Refuse
4705 Weiss Rd.
Frankenmuth, Saginaw Co.

Site Number 38

RSAS Screen: 41   RSAS Score: 411   SAS Screen: 5   SAS Score: 233

This 10 acre site is licensed as a domestic/commercial waste transfer station but waste is believed to be buried on site. Garbage and trash covers the property and leachate from the west of the property contains chromium (1,900 pb), zinc (340 ppb), nickel (47 ppb), and copper (1,000 ppb). Phenols and ammonia were also detected but interferences kept them from being quantified. The site is bordered to the north and east by a foundry sand fill owned by General Motors so it is possible that the metals may be attributed to that fill.

The Saginaw River lies 700 feet to the west and storm water ditches collect the leachate and discharge to the river. The river is used for recreation, not drinking water. Marinas and public accesses, are located within three miles downstream.

No homes on private wells nor municipal supply wells are located within the 1/2 mile radius. Soils generally consist of 60 to 80 feet of yellow or blue clay over 20-25 feet of hard pan. This overlies more than 100 feet of shale. One school and no hospitals are located within the 1/2 mile radius. The air population at risk is estimated at 2,628 people while the direct contact, surface water population is estimated at 18,395 people.

SITE DESCRIPTION

Darling Road Dump
Plank and Darling Roads
Milan, Monroe Co.

Site Number 39

RSAS Screen: 23   RSAS Score: 1287   SAS Screen: 7   SAS Score: 704

This was a private land parcel whose owner accepted drums of unidentified liquid waste. The property was never licensed as a landfill. At the time of citation, 2578 drums were located in an area approximately 1 1/2 acres in size. Drums had leaked and soils were contaminated. Runoff from the property had also contaminated an adjacent unnamed county drain. The drain flows to the Saline River approximately 3/4 mile to the southwest.

The drums have been removed by the State but approximately 3,000 cubic yards of contaminated soils and drain sediments remain. PCBs, as arochlor 1254, have been found in concentrations ranging from 820 to 29,700 ppm. Cyanide (60 ppb), toluene (9 ppb), ethylbenzene (8 ppb) and xylene (11 ppb) have also been found in soils.

Six homes within the 1/2 mile radius in the direction of projected ground water flow (toward the Saline River) are on private wells. Soils in the area are clay and allow little infiltration. One to two feet of peaty clayey loam overlie 65 to 100 feet of gray clay. No significant wetlands are in the area and water runs off rapidly due to the extensive county drain network. The Saline River is used for recreation, largely fishing but also some boating, and is lined with homes. No schools or hospitals lie within the 1/2 mile radius.

SITE DESCRIPTION

Osceola County Road Commission
800 S. Chestnut
Reed City, Osceola Co.

Site Number 40

RSAS Screen: 17 RSAS Score: 358 SAS Screen: 1 SAS Score: 195

This site is the county road commission salt/sand pile staging area for road deicing supplies. The pile and spread area covers approximately 1 acre and is uncovered and unlined. Soils are saturated and white with salt when dry and no vegetation grows in the affected area. Runoff is to the street ditches which flow to the Hersey River approximately 3/8 mile to the south. The Hersey River is used for recreation, especially boating, and the nearby stretch has a fish advisory due to contamination upstream from The Old Koppers site.

This area is outside the municipal supply system and 43 homes within the 1/2 mile radius are on private wells. Soils in the area average 16 feet of sand with a few discontinuous lenses of clayey sand over 13 feet of gray clay. The underlying aquifer is at least 11 feet and consists of sand and gravel. Significant wetlands are found along the river. No schools or hospitals lie within the 1/2 mile radius.

SITE DESCRIPTION

Groundwater Contamination Peninsula Twp. Site Number 41
All sections of Peninsula Twp.
Grand Traverse County

RSAS Screen: 31 RSAS Score: 766 SAS Screen: 8 SAS Score: 606

Peninsula Township is a narrow strip of land extending north from Traverse City into the Grand Traverse Bay of Lake Michigan. The peninsula is 22 miles long with an average width of 1 mile and totals 19,072 acres. Most of this area was deforested prior to the turn of the century and the major agricultural replacement crop since 1930 has been cherry orchards. As of 1980, 40% (7,690 acres) of the township was planted with orchards, 11% was residential and 19% remained forested. From the 1930's to mid-50's, animal manure was the predominate fertilizer used on the cherry orchards in quantities of 1-5 tons per acre per year depending on the orchard maturity. Ammonium nitrate, area, and calcium nitrate are currently being used. Mature cherry trees (which represent about 2/3 of the total orchard acreage) receive about 400-750 lbs of ammonium nitrate (or equivalent nitrogen fertilizer) per acre per year. The average annual precipitation in the area is about 30 inches.

In the early 1970's nitrate concentrations approaching and/or exceeding 10 mg/l were recorded in 17 wells in Peninsular Township. Several research projects were undertaken to evaluate the problem, but no single source was positively identified. Cherry orchard fertilization and septic tank effluents were indicated to be the two most potentially significant sources of groundwater contamination by nitrates. All residences of Peninsula Township use septic tank system for human waste disposal. In 1979 and 1980 the Northwest Michigan Regional Planning and Development Commission undertook a study to determine the extent of nitrate contamination. Out of approximately 1,400 wells on the peninsula, 1,212 wells were sampled. Eleven percent of these wells had nitrate concentrations ranging from 10-28 mg/l, exceeding the established safe drinking water criteria for nitrate.

Soils of the peninsula consist of 1 to 2 feet of sandy foam over sand. Occasional isolated lenses of clay are encountered but the aquifer is essentially the water table which is found from 11 to 29 feet below grade. The population within the area of contaminated wells is approximately 3833 people. Numerous fishing and hathing public access points are on the peninsula but no scoreable wetlands.

SITE DESCRIPTION

Ricci Well site Blue Lake Twp. Site Number 42
N. Sunset Trail
Kalkaska, Kalkaska Co.

RSAS Screen: 21   RSAS Score: 605   SAS Screen: 03   SAS Score: 580

The Ricci property is in the vicinity of an oil and gas field just south of Little Twin Lake. An industrial Waste hauler, Northern Tank Truck Service had been hauling production brine and dumping it on the Ricci property. Apparently, a neighbor, Theadore Mihalciuc took pictures and kept a log of the times the dumping occurred on the Ricci property. Diked pits were constructed to receive the brine but dumping apparently occurred over 43 acres of the property. Apparently, the pits were not lined very well and most of the liquid leaked away rapidly. The Ricci residential well and the Mihalciuc residential well just east of the Ricci property were sampled in 1980, with no contamination found in either well. Both are seasonal residences so variable pumping of the wells could be the reason no contamination (high chlorides) was detected. To date no impacts to local drinking water wells have been noticed.

Private wells serve 296 people between the Ricci property and Twin Lake 600 feet to the north and Little Twin Lake 200 feet to the east. Seventy four homes line the shores of the two Lakes and Twin Lake has a public access. Soils are entirely sand or sand and gravel with no confining layer. Depth to water is between 15 and 30 feet. Wetlands are found adjacent to both lakes.

SITE DESCRIPTION

Saginaw River, Saginaw Bay
Saginaw and Bay Counties

Site Number 43

RSAS Screen: 35 RSAS Score: 1542 SAS Screen: 9 SAS Score: 885

The site includes the Saginaw River from the Tittabawassee River confluence to eastern Saginaw Bay at a line connecting Tawas Point on the north shore to Point Aux Barques on the south shore. The Saginaw River sediments are contaminated with PCBs, heavy metals (including chromium, copper, lead, and zinc), TCDD, and dibenzofurans. Sources of PCBs include industrial discharges and municipal wastewater treatment plants. Concentrations vary: the highest levels are found in areas of former PCB dischargers and in some deposition zones. Sediments in Bay City and Saginaw have the highest levels of PCBs. The average concentration found in the Saginaw River was 3.78 mg/kg. Dredging of sediments in 1977 and 1978 reduced the volume of PCBs present but did not eliminate the contamination. Estimates of PCB discharge from Saginaw River to Saginwa Bay ranged from 263 to 277 kg/yr in two studies. PCB burden in the Bay has been estimated at 3.7 metric tons. Heavy metals, notably chromium, coper, nickel, zinc, and lead, also contaminate the Bay sediments. There is a fish advisory against eating fish from the river.

Throughout the area, drinking water is provided from an offshore intake in eastern Saginaw Bay within the site boundaries. The drinking water population is estimated at 22,780 people. Other water uses are recreational: boating and bathing. Significant wetlands are found along the river and bay. Schools and hospitals lie within 1/2 mile of the river and bay or are served by water taken from the bay.

SITE DESCRIPTION

Thumb Radiator Service
Route 21
Lapeer, Lapeer Co.

Site Number 44

RSAS Screen: 30   RSAS Score: 1618   SAS Screen: 8   SAS Score: 845

Thumb Radiator, a radiator repair shop, has an internal sump pump that overflowed causing wastes (radiator fluid and metals) to flow out behind building and down gradient into private owner's field. The site is located one mile east of the city of Lapeer and is generally rural. Even so, there are two homes within 1/10th of a mile of the site. A total of 19 homes are down gradient of the site. The exact quantity of waste is unknown, but it contains lead, arsenic, cadmium and ethylene glycol. Soil concentrations of 19 ppm arsenic, 39 ppm cadmium, 96 ppm chromium, 65,000 ppm copper, 81,000 ppm lead, and 33,000 zinc have been detected. Since wastes flow on the surface, the danger of direct contact is high.

Soils are generally 60 to 80 feet of sand and gravel overlying 40 to 50 feet of clayey gravel. The aquifer is greater than 100 feet of limestone, sometimes overlain by 10 feet of shale. The south branch of the Flint River is approximately 500 feet south of the site. Extensive wetlands are located within the river floodplain.

SITE DESCRIPTION

Cannelton Industries/Tannery Disposal Site Number 45
3 Km West of Sault Ste. Marie
Sault Ste. Marie, Chippewa Co.

RSAS Screen: 36 RSAS Score: 1042 SAS Screen: 7 SAS Score: 629

Cannelton Industries of Charleston, West Virginia owns the property on which the defunct tannery, Northwestern Leather Company was located. The tannery operated from the 1940's until 1955 when the Fiborn Limestone Company purchased part of the property. Fiborn purchased the rest of the property in 1958 and transferred the property to Cannelton Coal Company who subsequently became Cannelton Industries, Inc., subsidiary of Algoma Steel.

The disposal area used by the tannery consists of approximately 5 acres along the south bank and within the 100 year floodplain of the St. Mary's River. Four public access points are located within 2 miles of the site. An estimated 10,000 cubic yards of tannery wastes were disposed at this property. Wetlands border the site on two sides. Soils collected on-site and within the adjacent river sediments contain extremely high levels of chromium (20,000 ppm), lead (800 ppb), copper (1200 ppm), cyanide (500 ppm) and mercury. Groundwater samples collected in 1979 near the approximate middle of the disposal area were found to contain chromium (120 ppm), lead (800 ppb), manganese (1 ppm), and arsenic (600 ppm) well in excess of drinking water standards.

Local subsurface lithology is typified by approximately 100 feet of unconsolidated sand and gravel. The underlying sandstone bedrock aquifer appears to be at least 900 feet thick. Domestic water wells draw water from the unconfined sand and gravel aquifer. No homes within a 1/2 mile radius are on private residential wells. The nearest domestic well appears to be approximately 6500 feet southwest of the former tannery disposal location.

Access to the surficial waste materials is unrestricted and poses a direct contact concern. The waste self combusted on several occasions from 1986 through 1989. Two surface water intakes for municipal water supplies are located in the St. Mary's River. The intake for Sault Ste. Marie, Ontario is located approximately two miles downstream of the old tannery disposal site and sewes 3,800 people. The intake for Sault Ste. Marie, Michigan is located approximately one mile upstream of this site.

SITE DESCRIPTION

Allied Paper/Portage Creek/Kalamazoo River Site Number 46
Allied-Portage Creek-Kalamazoo River
Kalamazoo to Saugatuck, Kalamazoo, Michigan

RSAS Screen: 35 RSAS Score: 1308 SAS Screen: 8 SAS Score: 969

Allied Paper, Inc., a manufacturer of speciality papers, has operated paper mills in Kalamazoo, Michigan since 1925. In the past, polychlorinated biphenyls were used in the paper industry in the manufacturing of carbon tissue, carbonless copy paper, and as plasticities in printing inks.

114 tons of PCB sediments contamination has been documented from Bryant Mill pond to and including Lake Allegan. The predominant PCB species found were arochlor 1242 and arochlor 1254. The release of PCB from contaminated sediments is a continuing source of contamination to the down stream water resource. Kalamazoo River sediment is contaminated with PCBs from Portage Creek to Lake Michigan at Saugatuck, approximately 80 river miles. Extensive wetlands adjoin the Creek and River and include Bryant Mill Pond.

The presence of PCB's in river sediment, and the re-suspension of PCB contaminated sediments are thought to be the cause of PCB levels in fish which are above both the Food and Drug Administration and the State of Michigan food consumption level of 2 ppm (parts per million). This has resulted in a fish consumption advisory of the Kalamazoo River. The PCB contamination of Portage Creek and the Kalamazoo River has been documented since 1971 and the PCB contamination of fish in the Kalamazoo River System appears to be a continuing problem. The PCB levels of fish have not declined and have been documented in concentrations of up to 47 mg/kg. The Kalamazoo River is also one of the major sources of PCBs entering Lake Michigan. Numerous shoreline and public access points exist within the impact area. The population at risk to this exposure is estimated at 8,572 people. Drinking water supplies for part of the city of Kalamazoo as well as Otsego are taken from wells within 1000 feet of the river. The population sewed by these wells is estimated at 11,000 people.

The major historical source of PCBs in the Kalamazoo River appear to be wastewater discharge from paper industries. Allied Paper was the primary source of PCB discharge into Portage Creek from paper recycling operations involving carbonless copy paper. Wastes were deposited directly in wetlands in Bryand Mill Pond, completely filling the pond.

SITE DESCRIPTION

Whites Bridge Road Area Site Number 47
Whites Bridge Road
Lowell, Ionia Co.

RSAS Screen: 32 RSAS Score: 671 SAS Screen: 9 SAS Score: 789

The Whites Bridge Road area encompasses 40 acres of land in the NW1/4 of Section 29, Keene Township, Ionia County. During the early 1970's, this parcel of land was owned by Clarence Fuller, and was licensed as a sludge disposal area. The land has since been divided into 4 ten-acres parcels and is owned by the residents currently occupying the land. The sludge that was dumped in this area consisted of metal plating, metal extruding and the die-casting operations wastes. Three residence (Young, Dodd, and Vanspronsen) located on this site had their private drinking water well supplies contaminated with 1,2-dichloroethane (1 ppb), trichloroethylene (542 ppb) and/or tetrachloroethylene (2 ppb). The wells were sampled for heavy metal contamination and came up negative. Another possible source for the organic contamination is a vehicle maintenance area. The affected residential wells have been replaced with Act 307 funding.

Soil samples revealed the following contamination: cyanide (0-29 ppm), chromium, copper, lead, nickel, zinc, and trichloroethylene (0-2 ppm). An unnamed creek drains the lagoon area to a wetland south of the disposal area.

the useable aquifer is from 40 to 108 feet (average is 78 ft below grade consisting in average of approximately 50 feet of clay overlain and interspersed by sand and some gravel. The aquifer consists of sand and gravel greater than 16 feet in thickness. Private wells serve 72 people within the 1/2 mile radius. The direction of ground water flow is unknown.

SITE DESCRIPTION

Bay City Middlegrounds
Middleground Island
Saginaw River
City of Bay City, Bay Co.

Site Number 48

RSAS Screen: 34 RSAS Score: 582 SAS Screen: 9 SAS Score: 838

Bay City Middlegrounds Landfill is located on Middleground Island in the Saginaw River within the City limits of Bay City. All homes in the area are on the municipal water supply, whose source is a surface water intake 1 1/2 miles out into Saginaw Bay.

The site is actually two landfills approximately 20 acres in size, one on top of the other. The first, which began operation in 1960, consists of domestic and sanitary waste, probably with some industrial waste, placed in trenches 15 to 20 feet below grade. The trenches were dug into the water table below the Saginaw River surface elevation. Demolition waste and brush were placed in the bottom of the trenches and then sanitary disposal began. Waste is in contact with ground water. The landfill was clay capped in the 1970s. The second fill was constructed on top of the first fill and built up to elevations as much as 60 feet above grade before closure. This fill received a combination of domestic and industrial waste including liquids. The landfill was closed in 1984. The top clay cap was not keyed into the clay cap of the first fill.

Leachate outbreaks have occurred and a leachate collection system has been installed. Before the leachate collection system was installed, leachate was flowing directly to the Saginaw River. The following compounds and concentrations have been detected in monitoring wells in the fill itself: PCBs, 320; vinyl chloride, 35; methylene chloride, 220; 1,2 dichloroethylene, 280; trichloroethylene, 220; toluene, 4.2; xylene, 2.4; ethylbenzene, 0.68; and 1,4 dichlorobenzene, <10. All concentrations are in parts per million. The following compounds and concentrations have been detected in monitoring wells outside the fill area: PCBs, 240; methylene chloride, 10; 1,2 dichloroethylene, 26; trichloroethylene, 46; benzene, 5.4; toluene, 17; ethylbenzene, 11; and xylene, 31. All monitoring well concentrations are in parts per billion. Site fencing is incomplete but there is little traffic or activity on the landfill part of the island.

Numerous public access sites exist within the area and the shoreline population is estimated at 5040 people. Wetlands are found along the river and on the island itself.

SITE DESCRIPTION

Gelman Sciences, Inc. Site Number 49
600 S. Wagner Road
Ann Arbor, Washtenaw Co.

RSAS Screen: 41 RSAS Score: 1741 SAS Screen: 9 SAS Score: 886

Gelman Sciences, Inc. has been operating since 1959, manufacturing plastic membrans and filter. Production wastes contain, 4 dioxane and were disposed of in an unlined seepage lagoon until 1978. From late 1987 the amount of dioxane in the waste has been reduced and discharged to the municipal wastewater treatment plant, from 1978 to 1982 wastes were piped to a 3 million gallon open aeration lagoon; aerated, and spray irrigated on 15 acres of their property. From 1982 until 1987 the company used a deep well injection (to 6500 ft.) method of waste disposal, with the land application for backup purposes. Results from May 26, 1981, showed dioxane in lagoon samples at 0.09 ppm, tetrahydrofuran at 0.01 ppm, and acetone at 0.05 ppm. Honey creek to the north and (Third Sister Lake) to the west of Gelman Sciences indicate 1,4-dioxane at levels of 105 ppb in surface water and 65 ppb in the sediments. Potable water supply wells at businesses in an industrial park to the month were found to contain 132 ppb. The industrial park has been connected to the municipal water supply. The wetland to the north has also been found to be contaminated with 1,4 dioxane at levels ranging from 1-200 mg/l.

Monitoring wells have detected a zone of dioxane contain about 400 feet north of the seepage lagoon at concentrations of 50 to 200 mg/l. A groundwater plume has been detected about two miles to the northwest in a shallow aquifer with concentrations 1 to 5 ppb at the outer edge. A second groundwater plume in a deeper aquifer has been detected 1 1/2 miles to the northeast at levels of 1-5 ppb.

The air exposure population has been estimated at 3457 people while 363 homes outside the municipal supply area but with the 1/2 mile radius from the extent of known contamination are at risk. The shoreline and public access population has been estimated at 7712 people. Soils are generally 5 to 10 feet of sand overlying 10 to 15 feet of silty, sandy clay. The aquifer is approximately 200 feet thick consisting of sand and gravel with discontinuous clay lenses.

SITE DESCRIPTION

Torch lake
Lake Linden
Houghton, Michigan 49945

Site Number 50

RSAS Screen: 33 RSAS Score: 1583 SAS Screen: 6 SAS Score: 850

Copper mining operations in the vicinity of Torch Lake produced large volumes of mill tailings. Much of the lake shore and peninsulas consist of this material. At least 20 percent of the lakes original volume was filled with an estimated 200 million tons of copper ore tailings (Markham 1985). In addition, the lake received municipal and industrial trash, sanitary wastes and mine pumpage. Consequently, the sediments of Torch Lake are enriched with copper and other heavy metals.

Sampling and analyses of Torch Lake sediments indicate high concentrations of copper and other metals. Sediment concentrations of 1400-2400 mg/kg copper have been discovered while chromium, lead, and zinc have also been measured at levels of 25-40, 30-270, 15-25- mg/k respectively. Copper levels in the water columns have ranged from 20 to 80 ug/l since 1971. The Michigan Department of Public health has issued an advisory on fish consumption, as walleyes and saugers within Torch Lake have been found to contain tumors. This advisory is based on aesthetics, as it is not known whether these could be health effects associated with consumption of the tumorous fish.

Copper flotation techniques, implemented in 1916, utilized a variety of chemicals which have been implicated in tumor induction or liver problems and may be the cause of the fish tumors. These flotation compounds were discharged, along with most of the soils processed by flotation, into Torch Lake.

Private wells serve 3548 people within 1/2 mile of the lake. The shoreline and public access population has been estimated at 7025 people. Soils are sand and gravel till 200 to 60 feet thick overlying igneous role. Wells are completed in the till. Extensive wetlands surround the lake.

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List of References

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