The Changing Illinois Environment: Critical Trends

Technical Report of the Critical Trends Assessment Project Volume 5: Waste Generation and Management

Illinois Department of Energy and Natural Resources

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June 1994

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Volume 1: Air Resources

Volume 2: Water Resources

Volume 3: Ecological Resources

Volume 4: Earth Resources

Volume 5: Waste Generation and Management

Volume 6: Sources of Environmental Stress

Volume 7: Bibliography

Volume 5
Waste Generation and Management

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ABOUT THE CRITICAL TRENDS ASSESSMENT PROJECT

The Critical Trends Assessment Project (CTAP) is an on-going process established to describe changes in ecological conditions in Illinois. The initial two-year effort involved staff of the Illinois Department of Energy and Natural Resources (ENR), including the Office of Research and Planning, the Geological, Natural History and Water surveys and the Hazardous Waste Research and Information Center. They worked with the assistance of the Illinois Environmental Protection Agency and the Illinois departments of Agriculture, Conservation, Mines and Minerals, Nuclear Safety, Public Health, and Transportation (Division of Water Resources), among other agencies.

CTAP investigators adopted a "source-receptor" model as the basis for analysis. Sources were defined as human activities that affect environmental and ecological conditions and were split into categories as follows: manufacturing, transportation, urban dynamics, resource extraction, electricity generation and transmission, and waste systems. Receptors included forests, agro-ecosystems, streams and rivers, lakes, prairies and savannas, wetlands, and human populations.

The results are contained in a seven-volume technical report, *The Changing Illinois Environment: Critical Trends*, consisting of *Volume 1: Air Resources*, *Volume 2: Water Resources*, *Volume 3: Ecological Resources*, *Volume 4: Earth Resources*, *Volume 5: Waste Generation and Management*, *Volume 6: Sources of Environmental Stress*, and *Volume 7: Bibliography*. Volumes 1-6 are synopsized in a summary report.

The next step in the CTAP process is to develop, test, and implement tools to systematically monitor changes in ecological and environmental conditions in Illinois. Given real-world constraints on budgets and human resources, this has to be done in a practical and cost-effective way, using new technologies for monitoring, data collection and assessments.

As part of this effort, CTAP participants have begun to use advanced geographic information systems (GIS) and satellite imagery to map changes in Illinois' ecosystems and to develop ecological indicators (similar in concept to economic indicators) that can be evaluated for their use in long-term monitoring. The intent is to recruit, train, and organize networks of people — high school science classes, citizen volunteer groups — to supplement scientific data collection to help gauge trends in ecological conditions.

Many of the databases developed during the project are available to the public as either spreadsheet files or ARC-INFO files. Individuals who wish to obtain additional information or participate in CTAP programs may call 217/785-0138, TDD customers may call 217/785-0211, or persons may write:

Critical Trends Assessment Project
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Copies of the summary report and volumes 1-7 of the technical report are available from the ENR Clearinghouse at 1/800/252-8955. TDD customers call 1/800/526-0844, the Illinois Relay Center. CTAP information and forum discussions can also be accessed electronically at 1/800/528-5486.

FOREWORD

"If we could first know where we are
and whither we are tending,
we could better judge what we do
and how to do it..."
Abraham Lincoln

Imagine that we knew nothing about the size, direction, and composition of our economy. We would each know a little, i.e., what was happening to us directly, but none of us would know much about the broader trends in the economy — the level or rate of housing starts, interest rates, retail sales, trade deficits, or unemployment rates. We might react to things that happened to us directly, or react to events that we had heard about — events that may or may not have actually occurred.

Fortunately, the information base on economic trends is extensive, is updated regularly, and is easily accessible. Designed to describe the condition of the economy and how it is changing, the information base provides the foundation for both economic policy and personal finance decisions. Typical economic decisions are all framed by empirical knowledge about what is happening in the general economy. Without it, we would have no rational way of timing these decisions and no way of judging whether they were correct relative to trends in the general economy.

Unfortunately, this is not the case with regard to changes in environmental conditions. Environmental data has generally been collected for regulatory and management purposes, using information systems designed to answer very site-, pollutant-, or species-specific questions. This effort has been essential in achieving the many pollution control successes of the last generation. However, it does not provide a systematic, empirical database similar to the economic database which describes trends in the general environment and provides a foundation for both environmental policy and, perhaps more importantly, personal decisions. The Critical Trends Assessment Project (CTAP) is designed to begin developing such a database.

As a first step, CTAP investigators inventoried existing data to determine what is known and not known about historical ecological conditions and to identify meaningful trends. Three general conclusions can be drawn from CTAP's initial investigations:

Conclusion No. 1: The emission and discharge of regulated pollutants over the past 20 years has declined, in some cases dramatically. Among the findings:

- Between 1973 and 1989, air emissions of particulate matter from manufacturing have dropped 87%, those of sulfur oxides 67%, nitrogen oxides 69%, hydrocarbons 45%, and carbon monoxide 59%.
- Emissions from cars and light trucks of both carbon monoxide and volatile organic compounds were down 47% in 1991 from 1973 levels.
- Lead concentrations were down substantially in all areas of the state over the 1978-1990 period, reflecting the phase-out of leaded gasoline.
- From 1987 to 1992, major municipal sewage treatment facilities showed reductions in loading of biological/carbonaceous oxygen demand, ammonia, total suspended solids and chlorine residuals that ranged from 25 to 72%.
- Emissions into streams of chromium, copper, cyanide, and phenols from major non-municipal manufacturing and utility facilities (most of them industrial) also showed declines over the years 1987-1992 ranging from 37% to 53%.

Conclusion No. 2: Existing data suggest that the condition of natural ecosystems in Illinois is rapidly declining as a result of fragmentation and continual stress. Among the findings:

- Forest fragmentation has reduced the ability of Illinois forests to maintain biological integrity. In one Illinois forest, neotropical migrant birds that once accounted for more than 75% of breeding birds now make up less than half those numbers.

- In the past century, one in seven native fish species in Lake Michigan was either extirpated or suffered severe population crashes and exotics have assumed the roles of major predators and major forage species.

- Four of five of the state's prairie remnants are smaller than ten acres and one in three is smaller than one acre — too small to function as self-sustaining ecosystems.

- Long-term records of mussel populations for four rivers in east central Illinois reveal large reductions in numbers of all species over the last 40 years, apparently as suitable habitat was lost to siltation and other changes.

- Exotic species invasions of Illinois forests are increasing in severity and scope.

Conclusion No. 3: Data designed to monitor compliance with environmental regulations or the status of individual species are not sufficient to assess ecosystem health statewide. Among the findings:

- Researchers must describe the spatial contours of air pollutant concentrations statewide using a limited number of sampling sites concentrated in Chicago and the East St. Louis metro area.

- Much more research is needed on the ecology of large rivers, in particular the effects of human manipulation.

- The length of Illinois' longest stream gaging records is generally not sufficient to identify fluctuations that recur less frequently than every few decades.

- The Sediment Benchmark Network was set up in 1981 with some 120 instream sediment data stations; by 1990 the network had shrunk to 40 stations, the majority of which have data for only one to three years.

CTAP is designed to begin to help address the complex problems Illinois faces in making environmental policy on a sound ecosystem basis. The next edition of the Critical Trends Assessment Project, two years hence, should have more answers about trends in Illinois' environmental and ecological conditions to help determine an effective and economical environmental policy for Illinois.

WASTE GENERATION AND MANAGEMENT

ACRONYMS

ADME	Adsorption, distribution, metabolism, elimination
API	American Petroleum Institute
ATSDR	Agency for Toxic Substances and Disease Registery
BDAT	Best demonstrated available technology
BLC	Blood lead concentration
BOD^5	5-day biochemical oxygen demand
CAA	Clean Air Act
CAP	Capacity Assurance Plan
CDC	Center for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFCs	Chlorofluorocarbons
CMC	Central Midwest Interstate Low-level Radioactive Waste Compact
COD	Chemical oxygen demand
COSMAR	Committee on Surface Mining and Reclamation
CTAP	Critical Trends Assessment Project
CWA	Clean Water Act
CWRL	Cooperative Wildlife Research Laboratory
DDT	Dichlorodiphenyltrichloroethane
DENR	Department of Energy and Natural Resources
DIY	Do-it-yourself
DL	Detection limit
DO	Dissolved oxygen
DOE	Department of Energy
EDF	Environmental Defense Fund
EIS	Environmental Impact Study
EP	Extraction procedure
EPCRA	Emergency Planning and Community Right-To-Know Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Program
GAO	Government Accounting Office
GENS	National Survey of Hazardous Waste Generators
GI tract	Gastrointestinal tract
GIS	Geographic Information System
HRS	Hazard Ranking System
HWF	Hazardous Waste Fund
HWRIC	Hazardous Waste Research and Information Center
IACSWUAL	Illinois Advisory Committee on Sludge and Wastewater Utilization on Agriculture Land
IDMM	Illinois Department of Mines and Minerals
IDNS	Illinois Department of Nuclear Safety
IDPH	Illinois Department of Public Health
IEC	Illinois Enviornmental Council
IEPA	Illinois Environmental Protection Agency
IMES	Industrial materials exchange service
IOCC	Interstate Oil Compact Commission
ISGS	Illinois State Geological Survey
ISWS	Illinois State Water Survey
KHC	Known human carcinogens
LLW	Low level waste

LUST	Leaking underground storage tanks
MGD	Millions of gallons per day
MSW	Municipal Solid Waste
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NAS	National Academy of Science
NCP	National Contingency Plan
NEDS	National Emmissions Data System
NEPA	National Environmental Policy Act
NOV	Notice of Violations
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Act
OTA	Office of Technology Assessment
PA	Preliminary assessment
PAH(s)	Polynuclear Aromatic Hydrocarbons(s)
PCB	Pollution Control Board
PCBs	Polychlorinated biphenls
PCS	Permit Compliance System
PIMW	Potentially infectious medical waste
POTW	Publicly owned treatment works
PRP	Potentially responsible parties
PVC	Polyvinyl Chloride
RA	Remedial action
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RI/FS	Remedial investigation/feasibility study
ROD	Record of decision
RPCF	Regional pollution control facilities
RTI	Research Triangle Institute
SARA	Superfund Amendments Reauthorization Act of 1986
SB172	Senate Bill 172
SB442	Senate Bill 442
SDWA	Safe Drinking Water Act
SI	Site inspection
SIC	Standard industrial classification
SMLCRA	Surface Mined Land Conservation and Reclamation Act
SQG	Small quantity generators
SS	Suspended solids
SWM	Special Waste Manifest
TCLP	Toxicity characteristic leaching procedure
TRI	Toxic Release Inventory
TSCA	Toxic Substance Control Act
TSDF	Treatment, storage and disposal facilities
TSDR	Treatment, storage, management or recycling facilities
TSP	Total suspended particulates
UIC	Underground Injection Control
USBM	United States Bureau of Mines
USEPA	United States Enviornmental Protection Agency
UST	Underground storage tanks
VOC	Volitile Organic Compound

VOLUME SUMMARY

This summary highlights the major trends found in the CTAP waste generation and management report. It is organized in roughly the same way as the technical report; a discussion of solid waste generation, the Toxic Release Inventory (TRI), and issues related to waste management and remediation.

The number of environmental laws has grown over time. Wastes and discharges have been regulated at the federal, state and local level in a piecemeal fashion. The various environmental media (air, land, and water) have traditionally been treated separately, each having a distinct set of laws and regulations. However, the recent trend is toward multi-media regulation as reflected in the Toxic Release Inventory reporting requirements.

WASTE GENERATION

Long term data for wastes are difficult to find and interpret. Information is quite limited before the mid-1980s. Existing information was collected to meet specific regulatory needs and frequently is unsuitable for other uses. Adding to the difficulty is the fact that the definitions and reporting requirements change often, resulting in year to year data that are frequently not comparable.

Environmental laws and regulations have increased in number and complexity over the past few decades. Compliance with these regulations has changed the way wastes are perceived and managed. Command and control regulations helped create the economic incentive to foster progress towards prevention. The current trend in waste management is to develop voluntary programs which encourage companies to reduce the volume and toxicity of wastes generated.

At the federal level, solid wastes are regulated under the Resource Conservation and Recovery Act (RCRA) and are generally categorized as hazardous or nonhazardous. The definition of hazardous waste has changed over time and includes only a portion of the wastes that potentially threaten human health and the environment.

In Illinois, solid waste management is regulated by the Illinois Environmental Protection Act and Title 35 of the Illinois regulations. The regulations identify some solid wastes as "special wastes" including almost all industrial process, pollution control and wastes considered hazardous under the federal system. About 85% of Illinois' special wastes are not regulated under RCRA but are subject to state permitting and reporting requirements. Other wastes including municipal solid wastes, mineral extraction wastes, medical wastes and low level radioactive wastes may be subject to a combination of federal and state legislation.

Municipal Solid Waste

Municipal solid waste (MSW) includes such items as durable goods, food packaging, and miscellaneous inorganic wastes discarded from homes, commercial facilities and industry. Nationwide, MSW accounts for about 1% of the total solid waste generated. The national per capita MSW generation rate has increased from 2.66 pounds per day in 1960 to 4.3 pounds per day in 1990. While the bulk of MSW has traditionally been landfilled, by 1990 approximately 17% was recovered for recycling and reuse nationally.

IEPA reports statewide solid waste generation based on estimated pounds per person per day (ppd) factors. In 1987, Illinois solid waste generation rate was estimated at 4.7 ppd for non-urban areas and 5.5 ppd for urban areas. By 1992, the estimated solid waste generation rate rose to 6.2 ppd. These generation rates are not directly comparable to U.S. statistics as the type of Illinois waste considered in the calculations include more than just MSW.

National statistics estimate that MSW consists of about 37.5% paper and paperboard products, 17.9% yard waste and over 8% each of plastics and metals by weight. Illinois 1986 estimates of the composition of Illinois MSW (not including yard waste) show that paper products comprise the largest part of the MSW stream by weight. Non-durable paper comprised 26.7%, total paper packaging 24% and corrugated boxes 16.6%.

Hazardous Waste

Over 1000 Illinois industrial facilities are subject to hazardous waste regulation. Between 1982 and 1989 these companies reported generating between 400 and 500 million gallons of hazardous waste annually. In 1990 this figure jumped to over 1.4 billion gallons largely because of a definition change that brought certain common oil refinery wastes into the hazardous waste category.

Available information shows that the bulk of Illinois' hazardous waste is produced at a small number of facilities. About two-thirds was generated at oil refineries in 1990. Other industries accounting for large volumes of waste include metal platers, fabricators and finishers and paint producers.

About 90% of Illinois' hazardous waste is managed at the site of generation. The remainder is shipped to permitted treatment, storage, management or recycling (TSDR) facilities either in Illinois or out-of-state. However, about half of the facilities that generate hazardous waste send it off-site since it is not economical for them to treat, store or dispose of it on-site. Most of the waste is generated in a few counties with high population density or large industrial facilities.

Until 1985, Illinois exported more hazardous waste than it imported from other states. In 1990 out-of-state imports to Illinois commercial facilities equaled the amount sent to those facilities by Illinois industry.

Industrial Waste

In Illinois, nonhazardous industrial waste is considered special waste and comprises over 80% of all Illinois special waste. Special wastes are subject to manifesting and reporting requirements. Most of the available information about industrial wastes in Illinois is derived from manifest information.

A 1980 study initiated by IEPA reported that 20.3 million tons of industrial wastes were generated in Illinois including 8.1 million tons of coal mining waste. This study did not make the distinction between nonhazardous and hazardous industrial wastes. Based on 1990 manifest information, 12.26 million tons of nonhazardous special waste was generated in Illinois.

On-site disposal of industrial waste is quite common in Illinois. In 1980 approximately 60% of all industrial waste was managed on-site. Available information for 1990 nonhazardous special wastes estimates on-site disposal to account for 73% of all nonhazardous special waste managed.

Approximately 84% of nonhazardous special waste generated in Illinois are managed in the state's landfills. Other management alternatives for industrial wastes in the state include treatment, recycling or incineration.

In the U.S., the largest amounts of nonhazardous industrial waste are produced by the pulp and paper, primary metals, electric power generation and inorganic chemicals industries. Illinois figures for 1980 identified the chemical and allied products industry as generating the largest volume of industrial waste (almost 7.5 million tons out of 12.8 million tons generated statewide). In 1990, the industries producing the largest quantities of industrial process waste included chemicals and allied products, primary metals and petroleum products.

Medical Waste

Medical waste has a confusing regulatory history, as it was largely considered a municipal waste until recently. Federal agencies have defined it in ways designed to protect either health workers or as a solid waste. Illinois has over 14,000 medical facilities including hospitals, labs and dental clinics. These are the largest generators of medical waste. Veterinary clinics, funeral homes and similar facilities add to the potential universe of generators.

Approximately 85% of the medical waste stream poses no greater threat than household waste unless it contains infectious items. Sharp instruments found in waste and the potentially infectious components pose the largest threat. Illinois has regulated infectious waste since 1985 and in 1991 passed legislation to greatly increase the regulation of these wastes.

The number of hospitals and beds declined sharply between 1972 and 1989, during which time surgical procedures increased by 21%. The use of disposable plastic and paper items continues to increase, indicating that waste disposal problems will continue.

Medical wastes generally contain about 95% paper and plastic making incineration on-site a primary means of disposal at medical facilities. Small incinerators are used. These may be inefficient and result in inconsistent effectiveness due to frequent start ups, part-time operators, variations in the waste stream and other reasons. New regulations are pushing medical waste management toward the use of off-site facilities and autoclaving.

Low Level Radioactive Waste

Low Level Radioactive waste (LLW) refers to unusable radioactive materials and materials that have been radioactively contaminated. The management of LLW is regulated by state and federal agencies. Since 1985 Illinois generators of LLW have been required to provide information to the Illinois Department of Nuclear Safety about the quantities and types of LLW stored or shipped.

It was estimated in 1991 that there were 347 LLW generators in Illinois. The bulk of these are medical facilities. The number of LLW generators has increased from 245 in 1984. Over 274,000 cubic feet of LLW was shipped off-site from Illinois generators in 1991. The volume of LLW shipped has fluctuated due to one-time events. Over 90% of the LLW shipped from Illinois generators is from reactors. Other types of generators (fuel-cycle, medical, industrial, academic and governmental) shipped proportionally large volumes in the early years of reporting but these volumes have since declined. The total amount of radioactivity shipped (as measured in curies) fluctuates dramatically depending upon the specific conditions of the use or process in any given year.

Mineral Extraction Wastes

Illinois has mined coal for over 180 years. Over 250 thousand acres of land have been affected by surface or strip mining of coal throughout the state. Of these, approximately 103,000 acres were disturbed prior to the state's first mining reclamation law in 1962. Wastes deposited and abandoned during this time were not subject to reclamation treatment of any kind. Between 1962 and 1977, approximately 84,000 acres were disturbed and wastes were subject to increasingly restrictive regulations. Since 1977, about 68,000 acres have been disturbed and all of the wastes disposed on these acres have been subject to the strictest reclamation laws.

Based on production statistics, over 18 million tons of coal related wastes were generated in Illinois in 1991.

Illinois coal mining-related laws are intended to protect the environment. Although environmental degradation occasionally occurs in relation to postlaw mining, most environmental problems are associated with prelaw abandoned sites. Abandoned mine waste refuse piles and unreclaimed soil represent potential sources of air pollution, erosion, and runoff (sedimentation), water pollution and aesthetic degradation. Approximately 9,000 eligible acres of prelaw wastes are still exposed to weathering that may break them down and release contaminants through erosion and runoff.

Minerals other than coal that are mined in Illinois include sand and gravel, microcrystalline silica (tripoli), ganister, novaculite, silica sand, stone, clay, shale, peat, and fluorspar. Direct mining of lead and zinc, primarily in northwestern Illinois, peaked in the 1850's and most of these mines were closed by 1975. Historical and current recovery of noncoal minerals has been documented at 1,870 sites across the state. Of these inventoried sites, between 450 and 700 (as of 1993) are active, noncoal mineral extraction sites. The Illinois Department of Mines and Minerals estimates, based on mine waste permits issued during the last 20 years, that acreage affected by noncoal extraction waste disposal is about 500 acres. Of these acres, about 250 are currently in use, primarily as slurry ponds.

Regulation of generation and management of oil and gas waste has begun in order to minimize potentially adverse environmental impacts. Mismanagement of the large volumes of produced water presents a greater risk to the natural environment and human welfare than does the disposal of other wastes generated by the oil and gas industry. Improper disposal of produced water (brine) has the potential to severely impact agricultural lands, crops, forests, streams, aquatic life, surface water, and groundwater. Oil production is on the decline in Illinois, so waste production associated with new drilling and well completion is also on the decline. Waste production associated with pumping oil from older wells is, however, on the rise because the ratio of produced water to oil is increasing as reservoirs become depleted.

Toxic Release Inventory

The Toxic Release Inventory (TRI) reports the release of over 300 chemicals to all environmental media. It is based on data reported by companies in compliance with the Emergency Planning and Community Right-to Know Act. The data base is quite useful but suffers from such problems as changing reporting requirements and estimated release amounts. As the only set of multi-media information about toxic substances released to the environment, TRI is useful for understanding the different ways that wastes may be managed and what management trade-offs result from changes in process or regulatory requirements.

In 1991, 1301 Illinois facilities reported releasing 311.3 million pounds of toxic chemicals to the air, land, water and off-site facilities. This contrasts with 938 facilities reporting in 1987. The 1991 report was the first to include information about specific source reduction activities undertaken by reporting facilities and expanded the reporting of off-site transfers to include recycling activities. As the result of some of these changes in reporting requirements, the average total release per facility has varied from 177,386 to 237,911 pounds.

Hydrochloric acid was the TRI chemical released in Illinois in the largest volume in 1991 - over 35.6 million pounds. It has consistently been one of the top chemicals released. Releases of zinc and zinc compounds, sulfuric acid and copper and copper compounds all exceeded 23 million pounds in 1991.

Transfers to off-site facilities in 1991 accounted for 42.2% of total releases. Air releases (fugitive and stack) and POTW releases accounted for 44.5% of TRI chemicals. Off-site transfer was most commonly used in 1991 for metals, energy and solvent recovery. Landfills and surface impoundments were often also the final destination of TRI chemicals.

The chemical and metals industries in Illinois have consistently been major contributors of TRI chemicals to the environment. Over 65% of the 1991 releases were from two industry groups; 117.8 million pounds were released from the chemical and allied product industry and 85.9 million pounds were from primary metals facilities.

The 1991 source reduction data estimated that 14.17 million pounds of reductions occurred between 1990 and 1991 as the result of activities undertaken by TRI facilities. Process modifications accounted for the largest portion of reductions - 8.67 million pounds. Over 37% of the reported reductions were from the chemical industry.

The geographic distribution of TRI releases and reporting facilities follows state industrial patterns. The Chicago and St. Louis metropolitan areas contribute large amounts of TRI chemicals.

WASTE MANAGEMENT

Landfills

For most of the 20th century, land disposal was the primary means of discarding solid waste in Illinois. It often took the form of an open dump or pit where waste was occasionally burned. Sanitary landfills became common after 1970, but often lacked liners and other protection. Regulations before 1975 frequently related only to litter control and disease vectors. Eventually public concern over groundwater contamination and related matters made landfills controversial.

Prior to 1981 Illinois landfills were sited wherever a developer could obtain a permit from IEPA. After that, the state's siting law, SB-172, required that such regional pollution control facilities obtain siting approval from the local government (before construction) in addition to receiving IEPA permits.

SB-172 has been controversial as it placed great power in the hands of local governments where landfills were planned for construction or expansion. However, between 1981 and 1988, 62% of landfill requests were approved at the local level.

The Pollution Control Board promulgated comprehensive landfill regulations in 1990 which when implemented greatly increase landfill safety. The regulations require liners, leachate collection, monitoring and other measures to protect groundwater. Additionally they require setbacks from wells, airports and other facilities and consideration of factors such as nearby natural areas.

Historically there are over 3000 identified sites in Illinois that at one time harbored a landfill or open dump. In 1987 there were 146 permitted nonhazardous landfills, a number that dropped to 106 by 1992. Changing landfill regulations are expected to help decrease this to 64 by the end of 1993.

IEPA surveys landfills annually to obtain estimates of remaining capacity. Despite the decreasing number of landfills, capacity has remained fairly steady. Estimated capacity rose from 273.6 million cubic yards in 1987 to 372.2 million in 1992. It's believed that this increase is largely due to the fact that new landfills are quite large.

The quantity of solid waste disposed in Illinois landfills has recently varied between 15.3 and 14.1

million tons per year. Landfilled hazardous waste varied between 194 and 359 thousand tons.

Fees charged at landfills have risen dramatically. In the Chicago area fees rose from $6.60 per ton in 1981 to $19.03 in 1989. In 1992 the average fee in Illinois was $7.42 per cubic yard and varied from $3.00 to $17.67. In contrast, fees for landfill disposal in some Northeastern states are over $100 per ton.

Recycling

Managing solid wastes through recycling has become an increasingly important tool to prolong landfill capacity in Illinois. By the early 1970's some Illinois companies and community organizations had already begun recycling programs. The passage of the Solid Waste Management Act of 1986, mandated goals for community recycling efforts were established, and lead to increased recycling by local governments. For example, the total tons of newsprint recycled in the town of McHenry rose from 153 in 1973 to 2664 tons in 1991.

In 1992, IEPA estimated that 11.4% of solid waste generated in the state was recycled at the 476 recycling facilities located in 57 Illinois counties. 41% of these facilities responded to a yearly IEPA survey and their data showed that paper is the largest portion of recycled materials followed by metal.

Success or failure of recycling programs is influenced by the volume of materials collected and a volatile marketplace. Because of the volatility in prices paid for collected recycled materials, facilities often find it difficult to maintain a steady cash flow. For example the price of old newspapers in Chicago was about $50/short ton in 1980, $35 in 1982, rose to $43 in 1988 and dropped to less than $10 in 1991.

Collection of recyclables by communities continues to increase. More industrial facilities are beginning to find it profitable to recycle rather than pay for disposal. In addition, used oil recycling is becoming more popular as a means of re-use and an alternative to disposal. Recycling, instead of appealing only to avid environmentalists is rapidly becoming the status quo.

Surface Impoundments

Surface impoundments are used for the retention, treatment and/or disposal of liquid waste. They may be located in natural topographic depressions, artificial excavations, or dike arrangements. The number of currently active or abandoned impoundments in Illinois is unknown. In 1980 IEPA conducted an inventory and assessment of surface impoundments and found approximately 7450 active or abandoned impoundments in the state. Almost half had been associated with the oil and gas industry for brine disposal. The remaining impoundments were associated with municipal sewage and water treatment, mining, industry and agriculture.

The primary concerns associated with waste disposal into surface impoundments are the potential to degrade or contaminate surface and underground sources of drinking water, render soils unsuitable for agricultural use, and pollute the air with dust from dried-up impoundment surfaces.

Land Application of Municipal Sewage Sludge

Federal and State policies regulate the transport, storage, land application and disposal of sewage sludge. Sludge must be treated so as not to present a threat to the environment or to public health. This treatment is accomplished by Publicly Owned Treatment Works (POTW's).

Large POTW's are associated with urban areas, process more industrial waste, and more commonly have pre-treatment programs than small POTW's. They are located primarily in the metropolitan Chicago area; this region accounts for approximately two thirds of the state's sludge production. The sludge processed by large POTW's contains higher concentrations of arsenic, cadmium, chromium, mercury, molybdenum, nickel, zinc, copper, and lead. These metals are necessary (in small amounts) for plant growth. Sludge also contains nitrogen and phosphorus, the primary plant fertilizers. Because of this, sludge "use" is encouraged under state and federal policies. Use may include the application to agricultural or non-agricultural land, landscaping, horticulture, or land reclamation. Sludge disposal may be to landfills, incinerators or sludge lagoons.

In 1989, approximately 45% of the over 178,000 metric tons Illinois POTW sludge outside the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) was landfilled. Thirty-four percent was applied to agricultural land, 11% was put into storage lagoons. The remaining 10% was put on dedicated land or used for land reclamation, horticulture, public distribution and other purposes.

Underground Injection Wells

Underground injection is defined as the controlled subsurface emplacement of fluids into select buried geologic formations. Five classes of underground injection wells are regulated in the state. The types of waste managed by underground injection include hazardous, nonhazardous, oil and gas by-products, mineral extraction and various wastewaters resulting from commercial or agricultural activity.

Class I wells in Illinois are used to dispose of more than 300 million gallons of industrial waste per year. The waste streams, both hazardous and nonhazardous are largely comprised of water. Acids used in industrial processes are the most common constituents of the injected waste streams. Class II wells are used for the disposal of oil and gas process fluids. In 1990, approximately 13,000 class II wells were documented in Illinois. Class V wells are commonly used in Illinois for sewage disposal, stormwater, and other industrial drainage. In 1987 almost 2,000 class V wells were inventoried in Illinois. The IEPA suggests that the number of Class V wells in Illinois may be much higher. Drainage and sewage-related wells make up the majority of class V wells in the state.

Treatment Storage and Recycling of Hazardous and Industrial Wastes

Aside from traditional disposal techniques like landfilling, generators of hazardous and industrial wastes may manage these using various treatment, storage or recycling methods. As the state's landfill capacity for such waste declines and cost of disposal increase, innovative methods for management will become more important.

Beginning in 1983, state regulations required operators of hazardous waste treatment, storage and recycling facilities to report the types and quantities of waste that have been managed by various methods. Treatment and recovery methods for hazardous or industrial wastes include metals recovery, solvent recovery, aqueous inorganic (or organic) treatment, sludge treatment and stabilization. The volume of hazardous waste treated or recovered in Illinois grew from about 180 million gallons in 1983 to almost 250 gallons in 1987. Treatment and recovery dropped again to 184 million gallons (about 760 thousand tons) in 1988 but then jumped substantially to over 5 million tons as oil refinery wastes were added to the regulatory definition of hazardous waste.

Storage is a common and low-cost method for handling waste when treatment or disposal is not cost effective. Concerns have been raised that long-term storage practices may pose a threat to the environment due to ground or surface water contamination or incidents of fire or explosion. Regulatory requirements have reduced improper disposal practices; concerns about storage in surface impoundments have prompted stricter requirements. In 1990, over 125 thousand tons of hazardous waste was stored at permitted facilities. Often these wastes are later shipped off-site for permanent management.

As the costs of disposal rise, recycling of hazardous and industrial wastes has become more common. The Illinois Material Exchange Service (IMES) is among state efforts to encourage recycling. IMES serves as a clearinghouse and market facilitator for hazardous and nonhazardous by-products that might otherwise require disposal. Since 1981, IMES has helped divert over 54.7 million gallons of material from landfill disposal and has saved Illinois companies close to fifty thousand dollars.

REMEDIATION ACTIVITIES IN ILLINOIS

In response to contamination cases such as Love Canal, Congress enacted two major pieces of legislation. In 1976, the Resource Conservation and Recovery Act (RCRA) was passed as a regulatory program for managing hazardous waste; from generation to disposal. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) established a national program for identifying, assessing and cleaning up abandoned contaminated sites. A detailed procedure was established for inventorying, assessing and ranking sites potentially eligible for federal cleanup funds. This Act has become known as Superfund.

As the result of Superfund legislation, contaminated sites across the country were inventoried. Based on the types of chemicals present and potential threat of release, these were ranked to establish priority for cleanup funds. Those ranked highest were placed on the National Priorities List (NPL) and are first eligible in the federal remediation process.

The main concern with these waste sites is potential human exposure to hazardous substances released from waste disposed and industrial sites by direct contact with contaminated air, soil and water or indirect exposure from contaminated food chains.

As of 1990, there were over 1360 Illinois sites identified in the federal inventory as potentially eligible for Superfund status and remediation. Of these, 38 ranked high enough to be placed on the National Priority List (NPL). As of December 1992, 40 Illinois sites were on the NPL.

Illinois legislation was enacted to provide money for clean-up of sites not eligible for federal funds. At least 37 sites in the state have been cleaned with state funds. The money available in the clean-up fund has not been sufficient to meet demand. A backlog of 105 sites exists.

USEPA estimates that complete remediation of any site could be accomplished in 6.5 years. In reality, the process can take much longer and be much more expensive than initially determined.

The issue of remediation is complicated by the fact that no consensus exists among agencies or environmental groups about how to define "clean". This question affects the appropriate level of cleanup at a site, the technology to be used and the point of compliance at which cleanup goals will be attained.

INTRODUCTION

USEPA's Science Advisory Board recently raised the question of whether the nation is addressing the most critical issues facing the environment. One suggestion for improvement is to take a more risk based approach to addressing the impact of various environmental contaminants. One of the objectives of the Critical Trends Assessment Project (CTAP) is to assess how Illinois' citizens impact the environment and how these impacts have changed over time. In the CTAP, trends for pollutants of concern to human health and the environment are discussed. This discussion covers traditional wastes and byproducts, their release to the environment and methods used to manage them.

This discussion of waste generation and management takes an holistic approach to the problem. Traditionally, waste is thought of as trash or garbage; the things that get thrown away (most likely in a landfill). When considering health and ecological aspects of the environment around us, all by-products of our modern lives, including air emissions and water releases, potentially impact our surroundings. This report focuses primarily on solid waste issues and land based management methods. Other media and methods receive a more cursory treatment.

Releases to the three major environmental media, air, water and the land occur every day in a variety of ways. Air pollutants are released via industrial smokestacks, automobile exhaust systems and household chimneys. Pollutants are released to water from septic tank systems, wastewater treatment plants or routine discharges from industrial facilities, storage sites and by air deposition. Solid wastes are generated at every level of society; from industry, government and individual citizens.

Solid waste management issues have traditionally received a large amount of attention from government and citizens because the disposal of such wastes are highly visible. Water quality issues have been a concern because of impacts on drinking water and recreational uses of water. Air issues, particularly toxic emissions, are a more recent concern as their implications on health effects have become better understood. As environmental awareness continues to increase, more attention will be paid to how the air, water and land collectively are affected by different components of society's activities.

This document touches upon how wastes have been viewed over time. It begins with an overview of current trends and the emergence of "pollution prevention" as a strategy for reducing waste. The latter requires a preventative approach throughout a product's lifecycle, before wastes are ever generated. The bulk of this report discusses various categories of waste and traditional means of managing them.

Waste types are diverse as are the many state and federal laws and regulations which apply to them. This diversity makes it difficult to discuss generation and management without risking confusion. For example, household, nuclear, medical and industrial wastes all pose "hazards", but all are not classified as "hazardous". The same material may be viewed differently under various laws and regulations. Additional complexity is introduced by the fact that laws and regulations frequently change as does the body of scientific information regarding risks.

This report is a starting point from which to consider how wastes influence our environment. The scope and depth of the analysis is limited, in some cases severely, by the kinds of information collected and retained by waste generators and required by environmental regulations. In some cases analyses are limited by the variability of the data bases and changing volume of waste from year to year as regulations change. In other cases analyses are limited by the large volumes of data and the limitations of staff and time to fully interpret them.

Where possible, government records and databases have been used to compile Illinois specific data. Often, such information is supplemented by literature and reports with a national focus, providing background information or suggesting future topics of study in Illinois. Throughout this report only data available at the time has been summarized and highlighted. The reader is urged to go to the HWRIC, the IEPA, the USEPA or other sources for more detailed data and reports on any topic.

Many questions have been raised as the result of writing this volume. Many of these will be addressed in the future as better information becomes available. One of HWRIC's long-term goals is to continually update Illinois waste generation and management information and report on these data. This document can serve as a starting point to understanding the complexity and nature of these issues.

OVERVIEW OF WASTE MANAGEMENT ISSUES AND TRENDS

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The management of wastes has gone from dumping freely into our water bodies or on the ground, to regulating wastes in terms of the concentration that could be released or the types of treatment and disposal that will be allowed (end-of-pipe approach), to the current trend of encouraging companies to implement pollution prevention strategies (that is, to reduce waste at the source, within the industrial facility, before it is ever generated). This chapter will consider some of the current trends that are occurring in our efforts to better manage wastes, and some of the issues facing us in this effort. The examination of historical trends on amounts of wastes that were managed was limited to a significant degree because of the lack of data. Some of the issues involved with both past and present data related to wastes are discussed below.

HWRIC has obtained much of its data from the Illinois Environmental Protection Agency (IEPA). These data came from industries in the state who were required to report certain wastes or emissions as part of a regulatory program. In addition to obtaining data tapes from IEPA, HWRIC has sponsored 22 research studies to catalog data and develop a database on waste generation and management in Illinois. These studies included database design and development, analysis of trends in the types and rates of wastes generated, assessment of environmental risks, evaluation of geographic and spatial relationships and development of policy options. The conclusion reached in many of these studies is that there are significant limitations to the available data bases. These limitations are briefly discussed below and in more detail in a recent paper by Thomas and Miller (1992).

Hazardous waste data are compiled largely by regulatory agencies from information required to be supplied by regulated companies. Variations in the quality of the data are due in part to the training of personnel collecting and reporting data and to differences in the accuracy of the waste measurements. Regulations require analysis of only a specific list of chemicals, which results in an incomplete characterization of the waste. Despite data limitations, significant time has been spent nationally trying to answer questions that available regulatory data are not designed to answer. For example, the current uses of existing data for new purposes such as measuring pollution prevention achievements and evaluating the risks to human health and the environment posed by the generation and management of wastes have not been especially successful. Additionally, state agencies often have inadequate resources to use the data that are submitted.

Despite these limitations, and the significant changes that have occurred in the various data sets collected in most cases as part of regulatory requirements, it is possible to identify some obvious trends in the way wastes are being managed and how these trends will effect future government programs and priorities. The following qualitative analysis attempts to outline some of the more significant trends that are occurring in the way wastes are prevented, managed and disposed in Illinois.

INCREASED DATA QUANTITY AND IMPROVED DATA QUALITY

There is no doubt that the quantity and quality of the waste data collected each year are improving. Measurement techniques are more sophisticated and the questions asked of generators about their waste have improved. But, it must be remembered that data about the generation of wastes are relatively recent. HWRIC staff have concluded that not until 1986 have the data on hazardous waste generation reached a degree of sophistication and reliability that warrant year to year comparisons. Although pre-1986 data are used in this report, they are not as accurate as more recent data.

Most of the data collected by the State of Illinois (as well as nationally) on wastes concern releases to specific environmental media. Thus the Clean Air Act requires descriptions of releases of certain chemicals to the air, the Clean Water Act regulates releases of certain chemicals to the water and the Resource Conservation and Recovery Act (RCRA) addresses hazardous waste destined primarily for disposal to the land. RCRA defines those wastes that should be classified as hazardous, although the law covers only a portion of the wastes that pose a potential threat to human health and the environment. A 1986 GAO report stated that "EPA does not know if it has identified 90 percent of the potentially hazardous wastes or only 10 percent, according to the division director responsible for hazardous waste identification." The separate reporting requirements, and the different chemicals and wastes reported for each media, make it very difficult to put together a complete picture of the wastes produced by any one facility in a year using existing data sets. An overview of various waste data sources, by media, is presented in Thomas et al. (1990) and summarized specifically in Table 2.1. This report focused on data that might be used to evaluate waste reduction activities in the state.

The Toxic Release Inventory (TRI) is the most useful data base for measuring pollution prevention because it deals with specific chemicals and their release to all media. It is the multi-media (e.g. releases of each chemical reported for air, water and land) and chemical (approximately 313 chemicals) specific aspects of this data base that have made it so useful. The value of the TRI data base has lead to a call for expanding the universe of chemicals covered under this reporting requirement. The Pollution Prevention Act of 1990 modified the Form R (the primary form generators used to report on releases of the 313 chemicals under TRI) to include information on source reduction by specific process for TRI chemicals. In the future, this source reduction information will be the best data to evaluate success of particular in-plant activities designed to reduce the waste generation of specific TRI chemicals. It will tie waste generation to some index of production and will increase our ability to compare the efficiency of similar processes.

The TRI program illustrates the value of having reliable data and how they can influence policy. When companies began to quantify the amount (often tons) of particular chemicals that they were releasing to the environment, it became apparent that these releases represented wasted money. It also created a public relations problem as communities became aware of the large releases coming from facilities in their area. Many companies initiated programs to reduce these releases, even when there was no particular regulatory mandate to do so.

A MOVE FROM COMMAND AND CONTROL ACTIVITIES TO POLLUTION PREVENTION

For over 20 years wastes have been regulated after they are generated. This was done by restricting the amount and concentration that could be released to the air or the water, restricting what could be released to the land, and in the case of hazardous waste, specifying how it had to be treated. Many people in our country operated under the paradigm that environmental protection and industrial productivity are incompatible; that is, environmental protection will be at the expense of industry and industrial promotion will result in environmental degradation. Recent studies by Templet (1993) indicate that in fact underspending on pollution control results in higher emissions and fewer jobs. Implementation of pollution prevention strategies provides industry an opportunity to increase efficiency and productivity while also enhancing protection of the environment.

To promote pollution prevention solutions requires development of new cooperative working relationships between industry and government. Since 1985 at least 45 states have established technical assistance programs to work cooperatively with industry to implement pollution prevention. And some 15 states have developed pollution prevention facility planning requirements, usually supported by state technical assistance efforts. These non-regulatory programs do not obviate the need for regulations and a strong regulatory agency, and in fact regulations and enforcement often drive companies to consider pollution prevention strategies.

Pollution prevention focuses on those processes within a plant that can lead to the generation of waste, as opposed to treatment or control of discharges after waste is generated. It requires the company to determine where and why waste are generated, and then to adopt strategies to reduce or eliminate those wastes within the plant. Pollution prevention strategies involve but are not limited to process changes; product reformulation; substitution of safer or less toxic raw materials; and improved training, housekeeping, preventive maintenance and accounting practices. A pollution prevention program is a business strategy, a way of operating more efficiently, and of putting more raw material into the product rather than losing it as a release or a waste. Investments to increase the efficiency of operation result in payback to the company, and may help them

Table 2.1. Overview of Various Waste Data Sources by Media

	Type of Release	Data Source[1]
Air	Fugitive Emissions:	
	Manufacturing Facilities	TRI
	Nonmanufacturing Facilities	None
	Stack Emissions:	
	Manufacturing Facilities	TRI, NEDS
	Nonmanufacturing Facilities	NEDS
Water	Point Sources:	
	Manufacturing Facilities	TRI, PCS
	Nonmanufacturing Facilities	PCS
	Nonpoint Sources:	
	Manufacturing Facilities	TRI
	Nonmanufacturing Facilities	None
Land	Hazardous Special Wastes Managed On-Site:	
	Manufacturing Facilities	TRI, GENS, Facility Annual Report
	Nonmanufacturing Facilities	GENS, Facility Annual Report
	Hazardous Special Wastes Managed Off-Site:	
	Manufacturing Facilities	TRI, GENS, Facility Annual Report, SWM
	Nonmanufacturing Facilities	GENS, Facility Annual Report, SWM
	Nonhazardous Special Wastes Managed On-Site:	
	Manufacturing Facilities	On-Site Industrial Waste Handling Report
	Nonmanufacturing Facilities	On-Site Industrial Waste Handling Report
	Hazardous Special Wastes Managed Off-Site:	
	Manufacturing Facilities	SWM
	Nonmanufacturing Facilities	SWM
	Nonspecial Wastes:	None

[1] Abbreviations used:
TRI=Toxic Chemical Release Inventory
NEDS=National Emissions Data System
PCS=Permit Compliance System
SWM=Special Waste Manifest
GENS=National Survey of Hazardous Waste Generators

Source: Industrial Waste Reduction: State Policy Options. HWRIC RR-044. 1990.

develop a competitive edge. Investment in end-of-pipe pollution controls or treatment rarely offers these economic incentives.

There is no doubt that a current major trend, both nationally and worldwide, is toward a pollution prevention/sustainable development philosophy. This has a number of potential implications, a few of which are briefly discussed below.

Less Reliance on Command and Control

As the focus becomes more preventive than regulatory, there should be less emphasis on the control of waste. Cooperative approaches between government and industry will become more common. One example is the USEPA's 33/50 program where industry has voluntarily agreed to participate in a program to reduce certain waste by 50% by the year 1995. Other cooperative programs are being initiated or considered by USEPA. And in Illinois, the IEPA has its Partners in Prevention Program which encourages companies to voluntarily develop pollution prevention programs and to find ways of reducing their waste. There is little doubt that the present regulations, the threat of new regulations, and the increasing cost of managing waste have increased the interest by companies in looking at voluntary programs and pollution prevention strategies.

Greater Focus on Multi-Media Releases

The TRI is the first data base to focus on multimedia releases. Some states have begun to do facility wide, multimedia permitting. At present, if air regulations increase in complexity or specific requirements, generators may find it easier and more economical to simply release the waste to the water or land. This however, does not reduce the amount of emissions to the environment. In the future, multi-media considerations may make this strategy more difficult and costly to implement. But to move to multi-media permitting will require major changes in the way regulatory programs are organized and operated.

Reductions of Waste Not Presently Regulated

In our present system, wastes tend not to be managed in any special way unless they become specifically regulated, their handling and disposal become very expensive, or they are deemed a potential liability to a company. In the prevention scenario, a company would begin to evaluate all of the wastes produced and released to all media, and develop strategies for their reduction. This should lead to significant reductions in all waste, not only those believed to be a threat to human health or the environment. This is important since, unfortunately, a number of chemicals once considered environmentally safe, such as PCBs and CFCs, are now major environmental problems. To address this issue some companies are trying to identify chemicals that may be restricted in use over the next 10 to 20 years, and to assure that their new products and processes will not depend on these chemicals.

Increased Productivity of Companies

Pollution prevention should ultimately provide greater environmental protection than the present regulatory approach, while facilitating increased industrial efficiency and productivity. The bottom line of pollution prevention is to efficiently turn raw materials into products rather than wastes. Some industrial facilities' pollution prevention efforts are saving millions of dollars per year in waste disposal and raw material costs. Increased production and product quality benefits are additional products of a pollution prevention approach.

Pollution Prevention Becomes Everyone's Job

While pollution control has traditionally been the responsibility of a company's environmental department, the trend is to make it part of each employee's job. In part this will happen when the true cost of waste is calculated, and charged back to the production or service unit within the facility that generated the waste. It will also begin to happen when each employee is held accountable for the waste generated as part of the employee's job.

Move to Clean Processes and Products

Some companies such as 3M require that before any new product is produced the waste implications of making and using it are addressed. The trend is toward taking a closer look at the waste implications of new technologies and products. This trend embodies the whole concept of sustainable development. Only through such careful planning and environmental concern can the next generation be provided with the same resources and opportunities that exist today.

INCREASED COST OF WASTE MANAGEMENT

The cost of managing waste continues to rise. This is due in part to the limited capacity of landfills and the public's aversion to incineration. The increased liability associated with possible remediation of contaminated sites has influenced the price that disposal companies charge. It has also encouraged companies to manage more of their waste on-site to reduce both the cost and potential liability of sending wastes off-site. Increasing waste management costs have driven many companies to examine prevention alternatives, in addition to ways of reusing or recycling waste, as a means of reducing their costs. Increased state fees and multiple layers of government involved in regulating a facility have also increased the cost to industry of their waste.

SITING OF LANDFILLS AND WASTE TREATMENT FACILITIES

The siting of these facilities has remained difficult despite the fact that technologies for treating waste and safely containing waste in landfills is much improved. Despite technological improvements there are fewer facilities, particularly municipal landfills. However, they are becoming larger and more regionalized. Many facilities in Illinois that already have permits are expanding, but relatively few new facilities are being built. In the future, waste may be shipped much greater distances to large facilities for treatment and disposal. This regionalization may make the Illinois siting process, SB172, which relies on local approval before permits are submitted to the IEPA, less workable if communities are more inclined to reject regional facilities.

LESS PUBLIC ACCEPTANCE OF RISK

The public concern about contaminants in the environment and work place has increased dramatically in recent years. This is due to a number of factors including improved knowledge, better characterization of wastes, improved understanding of the movement of waste through the environment, the ability to detect waste at lower and lower concentrations and the recent studies on the potential adverse health effects of low levels of certain chemicals. This concern has translated at times to an even lower level of risk being considered acceptable by the public. However, the clean up of contaminated sites to acceptable levels (low or negligible risk) may become prohibitively expensive. Because of uncertainties in some of the data on the degree of risk posed by many chemicals, and the large cost associated with any remediation efforts, many potential cleanup programs are held up in the courts for years.

THE NUMBER OF WASTE STREAMS BEING REGULATED IS INCREASING

The number of regulated waste streams is increasing with the result that there is an increase in reported waste. This is illustrated in the significant increase of hazardous waste generated in Illinois in 1990 versus 1991 (IEPA, 1992). Several major waste streams, such as those generated by mining and oil and gas extraction, will apparently be coming under increased regulation. This will greatly increase the volume of waste reported for the state. These new waste streams could have a major impact on present waste management systems in the state.

Some past waste management practices are generating increasing regulatory concern, and waste from these practices will have to be dealt with. For example, old coal gasification sites have been identified as potential problems and some are currently undergoing clean-up activities. There are over 100 of these sites in the state, some of which may have contaminated extensive areas.

Over 1,200 agricultural chemical distribution sites exist throughout the state. Activities at some have resulted in contamination of the soils and occasionally groundwater. If contaminated soils from many of these sites were to be disposed in landfills, it could tax the state's capacity to handle its other waste.

Leaking underground storage tanks have contaminated soils in most counties, and new sites are discovered frequently. What to do with these soils, and how to clean them to acceptable levels at reasonable costs is another major concern. The clean-up of these soils will continue to be a financial burden to the owners of sites and to the state for many years to come, although legislation proposed in the state legislature in the Spring 1993 is meant to reduce the financial and regulatory burdens on owners.

Industrial solid waste (nonhazardous) is a topic that is receiving considerable attention on the national level. USEPA is conducting a number of studies nationally to better define these wastes. A significant amount of materials going into Illinois municipal and special waste landfills is coming from commercial facilities and industry. Based on the Solid Waste Management Plans for 29 Illinois counties, 38% of waste going to landfills is residential, 32% from commercial or institutional sources, 20% is industrial and 9% is considered construction and demolition debris. Some of these wastes may pose a potential hazard that is as great as many highly regulated hazardous wastes (Plewa et al., 1986). There is no doubt that there will be more stringent requirements on how these wastes are managed in the future. At the very least there will be pressure on industry to reduce or recycle more of them.

CERTAIN CHEMICALS WILL BE PHASED OUT OF USE

The use of certain chemicals has been banned or greatly restricted, and these will play an ever decreasing role as environmental contaminants in the future. DDT and PCBs have been banned for years, and although they persist as environmental contaminants, their levels are decreasing. Lead levels in the air in Illinois have shown a steady decrease as leaded gasoline has been phased out (Sweet, et. al., 1990). Chlorofluorocarbons (CFCs), a major depleter of the ozone layer, are being phased out worldwide. Other chlorinated solvents are being targeted for substitution or reduced use at industrial facilities. Some printers in Illinois have switched from solvent based to water based inks. This type of switch will usually result in decreased air emissions but could increase releases to the water. A number of printers have started using soy oil (versus petroleum oil) based inks because the soy oil usually results in less air emissions and comes from a renewable resource. The total environmental tradeoff of some of these substitutions is unclear at this time but is being addressed by some scientists through life cycle analyses.

Asbestos use has been greatly restricted and it has been removed from buildings in large quantities. The contribution to landfills resulting from asbestos abatement has not been well documented but is probably significant. Likewise, use of a number of heavy metals has been restricted, including mercury and hexavalentchrome. Both contaminants are toxic and persistent in the environment. Batteries that contain these metals are being phased out as are other products and processes that use these metals. Batteries may end up being totally restricted from municipal landfills. More recycling of these metals in the future is likely.

Polychlorinated biphenals (PCBs) were widely used for insulation in transformers. Their persistence in the environment, their ability to bioaccumulate and their potential for causing adverse environmental and health effects, including cancer, has caused their use to be banned. Because PCBs were so widely used they are a common contaminant at numerous Superfund sites in Illinois (Crab Orchard, LaSalle-Peru and Waukegan Harbor), and their levels in fish have caused bans on eating or selling many fish in the Great Lakes region. Cleaning up sites of PCB contamination and destroying PCBs that still remain in insulators, motors, etc. will continue to be a major environmental challenge.

INCREASED FOCUS ON CONTAMINANTS GOING TO THE AIR

Like TRI, the new Clean Air Act Amendments have increased the attention and focus on atmospheric contaminants. For some cities this will result in restricted travel by automobile and major limitations on releases by new and old industrial facilities. The use of ozone depleters and smog forming chemicals will be greatly restricted in these areas. Improved and technically advanced monitoring equipment has allowed more accurate detection of various atmospheric contaminants and has brought greater attention to the types and amounts of chemicals released to the air. This public attention has prompted many companies to reduce releases to the air. In areas of high atmospheric contamination, such as the Los Angeles basin, there has been a move to regulate individual behavior, such as the use of cars, paints and even charcoal lighter fluid.

GREATER EMPHASIS ON RECYCLING AND MARKET DEVELOPMENT

Especially in the area of post consumer goods there will be an increased emphasis on the reuse and recycling of materials. From papers, cans, and bottles, to batteries and used oil, the state and nation will continue to find better ways to recycle and to develop more stable markets for recycled goods. But in many cases either the infrastructure for recycling does not exist or the market for the materials is more limited than the supply. Government requirements to buy recycled goods and funds to help develop markets for recycled goods may help in this regard.

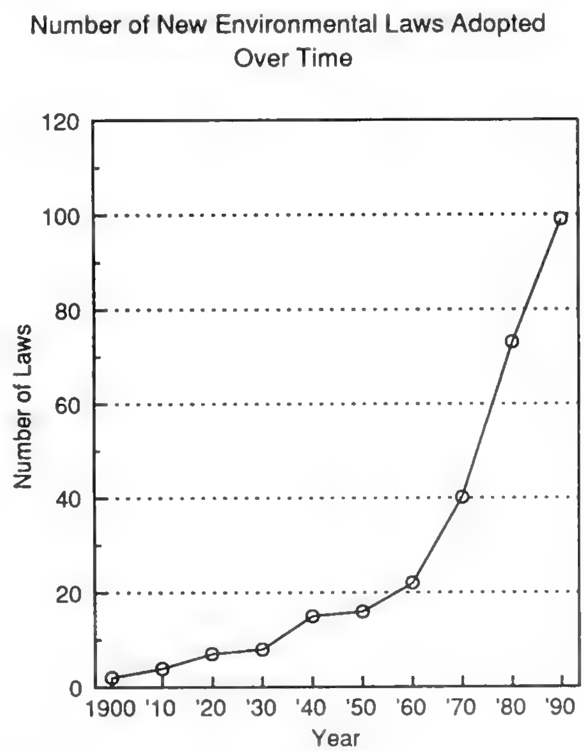
Industrial solid waste is another area that will also experience a significant increase in recycling activities. Companies throughout the state are not only recycling papers and cans, but have found markets for scrap metal, plastic, wood, oil, tires and other materials. As part of their overall pollution prevention programs companies are also finding ways to return a variety of raw materials back into their process, such as solvents and lubricating oils.

TREND TO TAX AND REGULATE RAW MATERIAL USE

Pollution prevention approaches require a company to consider the raw materials they are using. In some cases, companies are substituting a more toxic raw material with a less toxic one. The states of New Jersey and Massachusetts are asking companies to report throughput data (raw materials used, the amount that goes to product and the amount that goes out of the facility as waste). The Toxic Substance Control Act (TSCA) regulates new chemicals that are coming on the market. Some materials are being taxed such as gasoline to support the Leaking Underground Storage Tank (LUST) program, or chemical feedstocks to support the federal Superfund program for cleaning up past sites of contamination. The present trend in the country is to look more at the basic raw materials used by industry, not just the waste that is ultimately produced by various industrial processes. This trend is related to the trend to utilize more pollution prevention approaches to our current waste problems.

RAPID GROWTH IN VOLUME AND COMPLEXITY OF LAWS AND REGULATIONS

As environmental regulations have increased in number and complexity, industries have had increased difficulty in keeping up with the regulations. In addition, the expense in trying to comply with a "moving target" of changing environmental regulations has also created a burden on industry. Figure 2.1 shows the increasing rate at which federal environmental laws are proliferating. While increased reporting requirements and more complex measurements needed to meet these requirements may help a company better manage their waste, they have also created a burden on staff and increased cost to a company. Legislation has been introduced at both the state and federal level to help businesses, particularly small business. The new Clean Air Act calls for states to establish a Small Business Assistance Program. Such programs may lead to greater coordination between existing regulatory and non-regulatory programs. In Illinois, the legislature passed in June 1993 a "One stop shopping bill" aimed at assisting companies in their efforts to comply with various regulations and to expedite and speed the permitting process. The bill includes pollution prevention assistance. Pollution prevention programs, both statewide and nationally, are geared to provide a more cooperative environment in which government and industry can begin to economically solve some of our past waste management problems.



Source: Adapted from EPRI Journal January/February 1993

Figure 2.1

RISK BASED ENVIRONMENTAL PROTECTION STRATEGIES

Recent reports by the USEPA Science Advisory Board has called on USEPA to take a more risk based approach to environmental protection. One question that has been raised concerns whether we have adequately used our resources to address the environmental concerns of greatest importance. In some cases it appears agencies have allocated large amounts of resources to address environmental problems that may pose less risk than other more severe problems that have received relatively little attention. In fact, one of the drivers behind the CTAP project was to look at this very issue in Illinois and to provide the basis for recommendations for future environmental data gathering and protection strategies.

USEPA has explored various risk-based approaches in the past, but has often abandoned them because of a lack of adequate data. The difficulty of determining cause and effect between environmental contaminants and human and environmental health effects has lead in most cased to inconclusive results. It is our opinion that the risks of not asking the questions or trying to gather the appropriate data are too great to ignore. Ultimately we need to look at risk, and the potential impacts of our activities on human health and the natural environment. We need to identify data gaps and conduct the research needed to address these problems in a timely fashion. The preventive approach is the best and by far the least costly. This is apparent as the nation faces the almost overwhelming cost of cleaning up past contamination at industrial and municipal sites, and at federal facilities. In the long run, preventing future environmental problems is the only approach that will insure a productive society at a reasonable cost.

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WASTE GENERATION INTRODUCTION

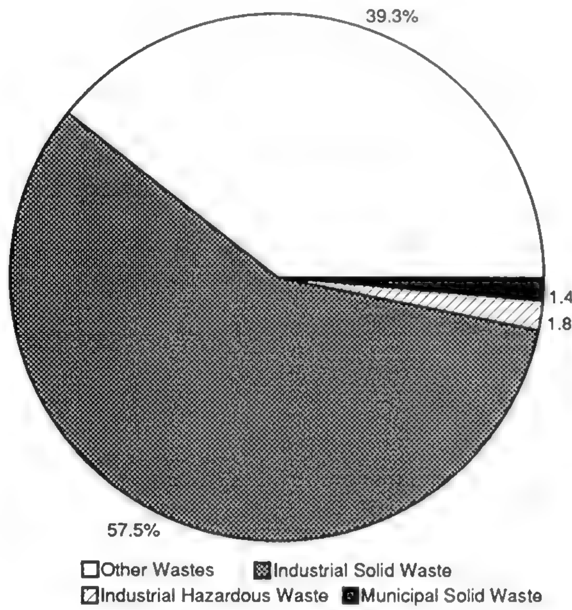
As the number of environmental laws has grown over time, wastes and discharges have been permitted and controlled at the federal, state and local levels in a piecemeal fashion. Each regulatory program provides a piece of an overall regulatory puzzle which is becoming increasingly complex. The various environmental media have traditionally been treated separately with air, land and water each having a distinct set of rules and regulations.

This discussion of waste generation and management focuses primarily on solid wastes. Waste generation is discussed relative to the quantities of waste generated, the components of these waste streams and how these wastes are managed. Where possible, the potential threats these wastes pose to the environment are addressed.

The Resource Conservation and Recovery Act (RCRA), passed in 1976 is the major federal statute regarding solid wastes. The act defines solid waste broadly to include almost every material resulting from industrial, commercial, mining and agricultural operations and community activity. Subtitle C of RCRA identifies some solid wastes as "hazardous" and details specific hazardous waste regulations. The permitting and reporting requirements for generation and management of RCRA hazardous wastes must be minimally adopted by each state's environmental program. Illinois' hazardous waste regulatory program is identical in substance to RCRA regulations. Most of the available information about hazardous waste generated and managed in the state is produced to fulfill federal RCRA subtitle C requirements.

All other solid wastes not identified as "hazardous" under subtitle C of RCRA are included in subtitle D of the act. These subtitle D wastes may include municipal, industrial, construction and demolition, agricultural, oil and gas exploration and production, coal combustion, municipal combustion ash, cement kiln dust and pollution control sludges. Nationwide, it has been estimated that over 13.2 billion tons of solid wastes are produced annually. This total includes both subtitle C and subtitle D waste among others. Figure 3.1 displays the relative size of major waste streams as estimated by USEPA (USEPA,

United States Solid Waste Universe
Approximately 13.2 Billion Tons Per Year



Other Wastes Include Mining, Oil and Gas, Utility, Cement Kiln Dust.

Source: Personal Communication, USEPA Jim Loundsbury, 1993

Figure 3.1

personal communication, Jim Loundsbury, 1993). Federally recognized hazardous wastes and municipal solid wastes, the two waste streams that receive the most public attention, together contribute only 3% of the entire solid waste universe. These wastes are relatively tightly controlled, compared to much of the remaining 97% of solid waste.

Subtitle D waste regulation is a topic increasingly being discussed at the federal level. States are currently responsible for developing their own programs for the regulation of subtitle D wastes. Illinois "special waste" regulations were adopted by the Pollution Control Board in 1979 and address RCRA subtitle C "hazardous" wastes, industrial process wastes and pollution control wastes. Figure 3.2 outlines solid waste characterization in Illinois, emphasizing the distinction between special and non-special wastes.

Illinois special wastes are subject to manifest requirements on the part of generators, transporters and management facilities. Those special wastes classified as RCRA hazardous are subject to federal reporting requirements. Nonhazardous special wastes were not subject to annual reporting requirements until 1991.

This discussion of waste generation includes sections about most types of solid waste and the Toxic Release Inventory. A recent trend is toward a multimedia approach to waste regulation, addressing waste released to all media collectively. This trend is reflected in the adoption of the Toxic Release Inventory (TRI) reporting requirements as part of the Superfund Amendments Reauthorization Act of 1986 (SARA).

SARA expanded and revised CERCLA to provide an emphasis on toxic chemicals currently present in the environment. SARA established the Emergency Planning and Community Right-to-Know Act (EPCRA) containing major sections related to emergency planning and public awareness. One of the major parts of EPCRA was the establishment of the annual toxic chemical release inventory.

TRI is not a regulatory program; it is a multimedia reporting requirement. Manufacturing facilities which produce and/or use any of a list of over 300 chemicals are required to report annually what has been released to all environmental media. TRI releases are estimated based on engineering or mass-balance calculations rather than manifested shipments of waste on which RCRA reporting is based. TRI reports the release of specific chemicals rather than wastestreams potentially composed of multiple components.

MUNICIPAL SOLID WASTE

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DEFINITION/BACKGROUND

As defined in USEPA's report "Characterization of Municipal Solid Waste in the United States: 1992 Update", municipal solid waste (MSW) includes:

> "wastes such as durable goods, non-durable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional and industrial sources." (EPA/530-R-92-019, 1992).

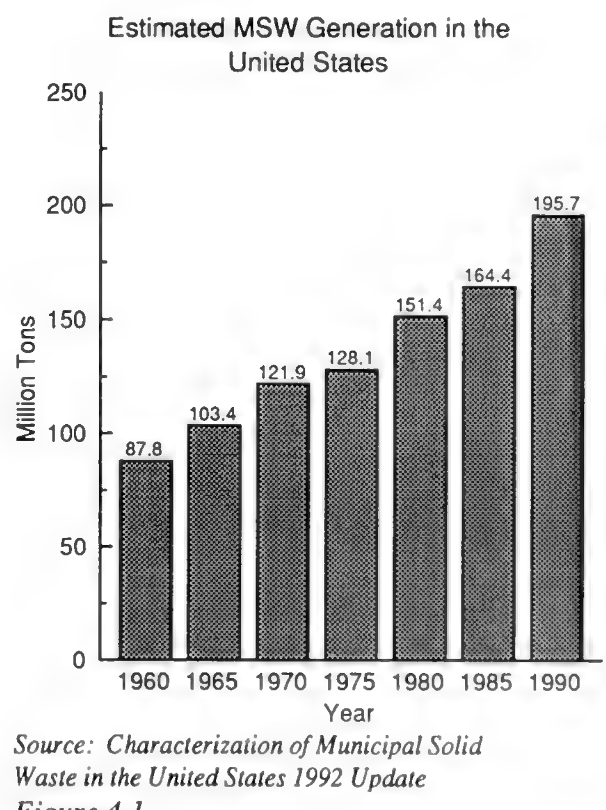
The definition of MSW does not include such wastes as municipal sludges, combustion ash, industrial nonhazardous process wastes and construction/demolition wastes although they may be disposed with MSW in landfills or incinerators. Most MSW is disposed in landfills. As the number of permitted landfills decreases and the costs of landfill disposal increase, landfill capacity has become a serious problem in some parts of the country.

The USEPA Municipal Solid Waste Task Force published a recommended national strategy in 1989 for improving the management of MSW. Their report, "The Solid Waste Dilemma: An Agenda For Action", provided goals and recommendations for USEPA, state and local governments, industry and private citizens to address MSW management issues. The task force suggested an "integrated waste management" framework consisting of source reduction, recycling, waste combustion and landfill disposal. The report emphasized the need for a shift to source reduction and recycling and repeated USEPA's stated goal of reducing by 25% the amount of waste sent to landfills and incinerators by 1992 (USEPA, 1989, p. 10).

NATIONAL MSW TRENDS

In conjunction with Franklin Associates, USEPA has produced a series of reports characterizing MSW in the United States. The most recent report includes MSW data from 1960 to 1990 and discusses the generation, recovery for recycling, composting, combustion amounts discarded or disposed, and a characterization of MSW.

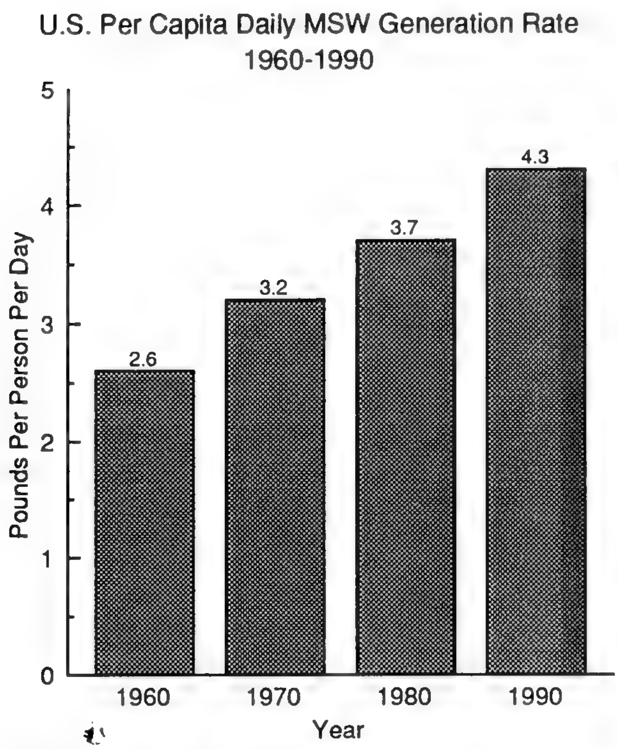
The authors used a material flows methodology to estimate quantities of MSW generated in the nation. The methodology is based on production data for materials and products in the waste stream. Nationwide, the generation of MSW has increased steadily since 1960, amounting to 195.7 million tons in 1990. Figure 4.1 displays this upward national trend as estimated by USEPA and Franklin Associates. The per capita daily MSW generation rate (before recovery or composting) has also been increasing steadily. This rate was estimated to be 4.3 pounds/person/day, up from 2.66 pounds/person/day in 1960 (see Figure 4.2).



Source: Characterization of Municipal Solid Waste in the United States 1992 Update

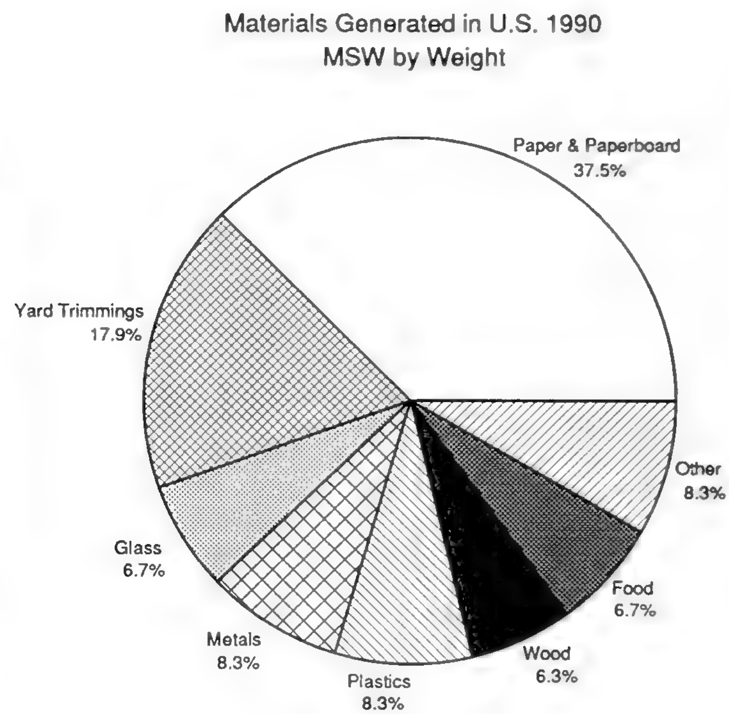
Figure 4.1

Franklin Associates also projected that with no additional efforts in source reduction, the amounts of MSW generated in 1995 and 2000 are expected to reach 208 and 222 million tons respectively. The projected increases in waste generation underscore the importance of the source reduction component of the integrated approach suggested by USEPA's "Agenda



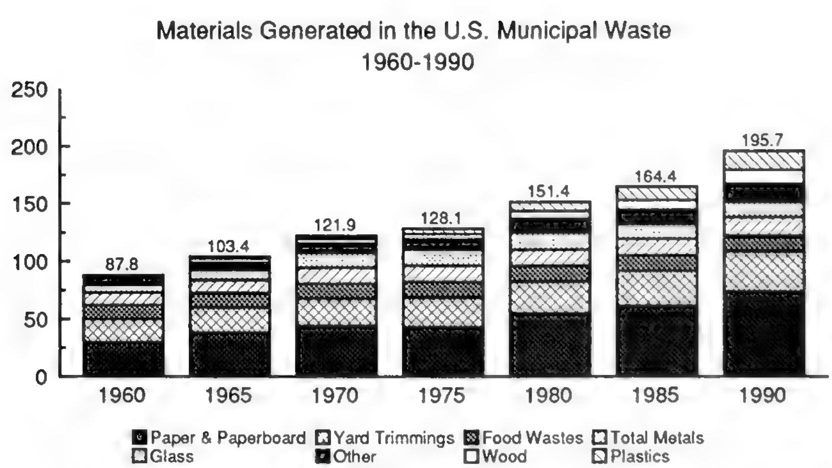
Source: Characterization of Municipal Solid Waste in the United States 1992 Update

Figure 4.2



Source: Characterization of Municipal Solid Waste in the U.S.; 1992 Update EPA/530-R-92-019

Figure 4.3



Source: Characterization of Municipal Solid Waste in the U.S.; 1992 Update EPA/530-R-92-019

Figure 4.4

for Action".

Paper and paperboard products constituted the largest portion of materials in the national MSW stream in 1990 (37.5% of the total weight). Yard trimmings comprised 17.9% of the total MSW. Figure 4.3 displays the breakdown of materials generated in MSW by weight in 1990. Since 1960, the amount of paper and plastics products generated in MSW has increased while the glass, metals, food wastes, and yard trimmings categories have shown a decline (Figure 4.4). Table 4.1 provides a comparison of the components between 1960 and 1990.

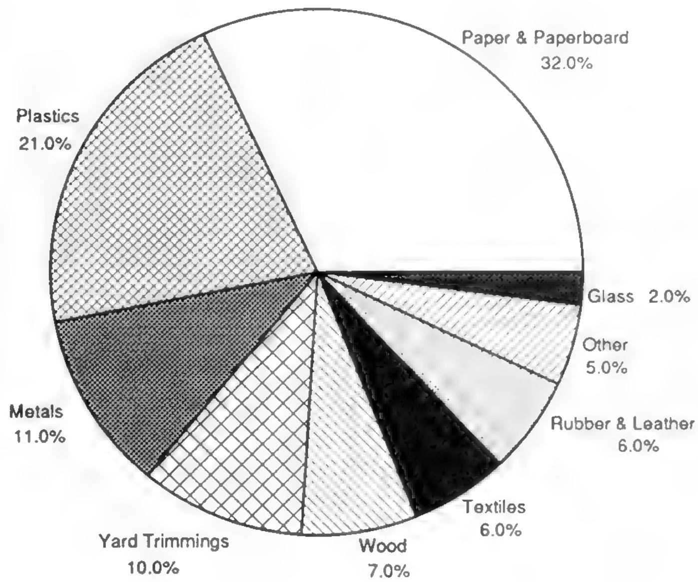
Table 4.1. Component Materials Generated in U.S. MSW, 1960 and 1990 (Estimated Percentage of Total MSW by Weight)

Material	1960 Percent of Total	1990 Percent of Total
Paper and Paperboard	34.1	37.5
Glass	7.6	6.7
Metals	12.0	8.3
Plastics	0.5	8.3
Rubber and Leather	2.3	2.4
Textiles	1.9	2.9
Wood	3.4	6.3
Other	0.1	1.6
Food Wastes	13.9	6.7
Yard Wastes	22.8	17.9
Miscellaneous Inorganic Wastes	1.5	1.5

Source: Characterization of Municipal Solid Wastes in the United States: 1992 Update; EPA/530-R-92-012; July 1992; p. 2-2.

Although solid wastes are usually characterized by weight, the space occupied by waste is also important. Landfills do not get overweight, their space fills up (EPA/530-R-92-019, 1992, p. 6-1). The density of the various MSW components was estimated based on experimental work and other sources. The densities were used to estimate the cubic yards of waste components disposed in landfills. Figure 4.5 displays Franklin Associates estimate of the components discarded in MSW by volume (cubic yards) for 1990. Most notable is the fact that plastics and metals comprise larger portions of the MSW disposed in landfills, by volume than by weight.

Landfill Volume of Materials in U.S. MSW, 1990

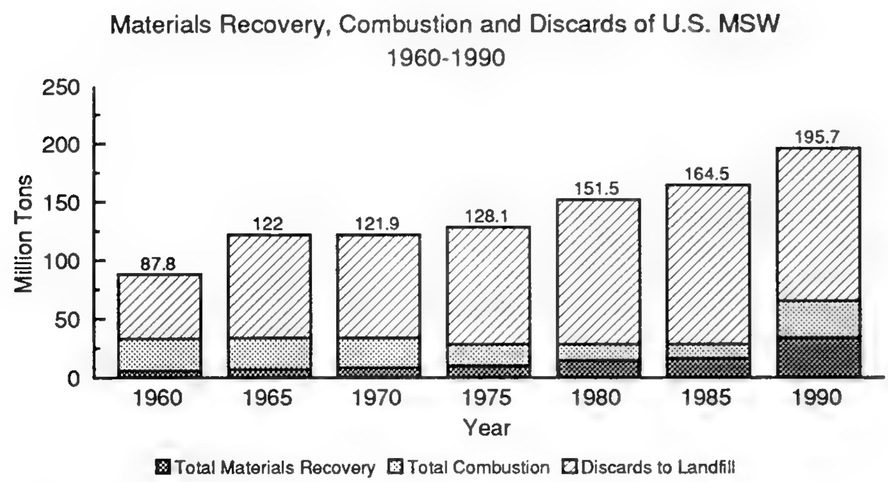


Source: Characterization of Municipal Solid Waste in the U.S.; Update EPA/530-R-92-019

Figure 4.5

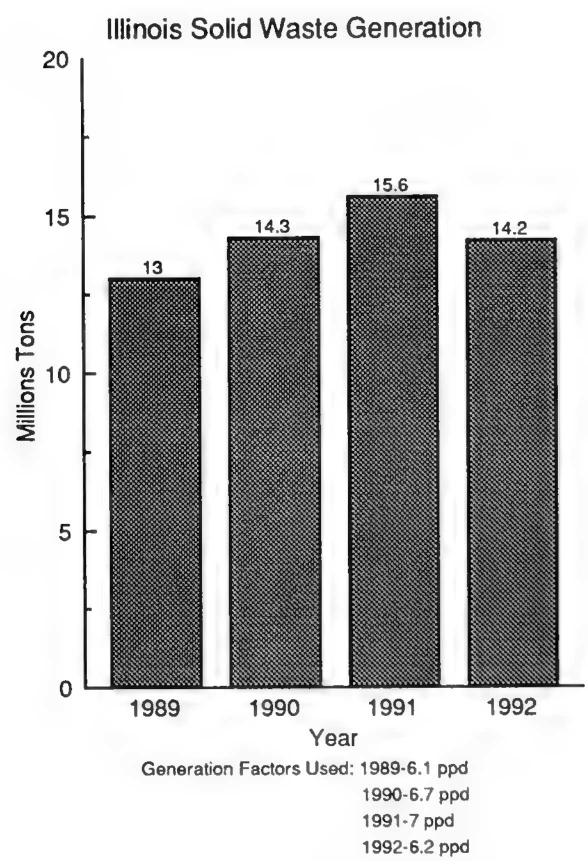
Approximately two-thirds of the MSW generated nationally in 1990 were discarded in a landfill. This is a decline from a 1985 high of 82.9% of MSW going to landfills. Recovery for recycling and composting has had an increasing effect on landfill discards with 17.1% of MSW being recovered in 1990. Figure 4.6 shows the relative use of recovery, combustion and landfills for the management of MSW from 1960 to 1990.

While the Franklin Associates analysis provides some reasonable estimates of MSW generation and management, determining the actual volume of MSW generated is difficult and different studies have reported widely different levels. Inconsistent reporting and definitions between this EPA/Franklin data and information collected on the state or local level as well as different legal and statutory requirements on the state and federal level make comparisons difficult. Local capacity needs and MSW composition issues are best addressed with information collected at the local level; national statistics, while useful, are not always appropriate for local decision making. If kept in perspective, national trends can provide a useful context for MSW trends identified in Illinois.



Source: Franklin Associates, Ltd

Figure 4.6



Source: IEPA Available Capacity for Solid Waste in Illinois 1989-1992 Reports

Figure 4.7

ILLINOIS MSW TRENDS

The increasing public concern over MSW and all other solid waste in Illinois lead to adoption of the Illinois Solid Waste Management Act (SWMA) in 1986. The SWMA's purpose is to help reduce the State's dependence on land disposal and help in establishing a state-wide approach to solid waste management. The approach outlined by the SWMA is similar in content to USEPA's agenda and established the following hierarchy for the management of solid wastes (in descending order of preference):

Volume Reduction
Recycling and Reuse
Combustion with Energy Recovery
Combustion for Volume Reduction
Disposal in Landfills

The SWMA empowered IEPA to collect a tipping fee for each cubic yard or ton of solid waste landfilled. The fee is collected from the landfill owner or operator based of the volume or weight of wastes accepted during the course of a year and is deposited in the Solid Waste Management Fund. The monies collected in this fund are used to provide financial assistance to local governments for solid waste planning purposes, to support the operation of the industrial materials exchange service (IMES) and other solid waste research needs. The Act also requires IEPA to publish an annual report regarding the disposal capacity available for solid waste in Illinois sanitary landfills. These reports have been published since 1987 and provide a source of information about the volume of solid waste managed at Illinois landfills.

Some nonhazardous industrial process wastes are included within the scope of the SWMA in addition to municipal waste, defined in Illinois as: "garbage, general household and commercial waste, industrial lunchroom or office waste, landscape waste, construction or demolition debris." Beginning in 1989, the fee, tax or surcharges under subsections (b) and (j) of the SWMA shall not apply to:

1) waste which is hazardous waste;

2) waste which is pollution control waste;

3) waste from recycling, reclamation or reuse processes approved by the agency as meeting specific criteria;

4) nonhazardous solid waste received at a sanitary landfill and composted or recycled through a process permitted at the agency;

5) any landfill permitted by the agency to received only demolition or construction debris or landscape waste.

IEPA estimated the generated amount of solid wastes for the required reports based on generation factors provided by local governments participating in the state planning grant program. Figure 4.7 displays the Illinois solid waste generation estimate for 1987 through 1992. These totals represent industrial as well as residential, commercial and institutional solid wastes.

As expected, the total volume of solid waste generated by county is highest in areas of greater population and higher industrial concentration. Figure 4.8 is a statewide map showing the volume of solid waste generated by county.

In 1989 DENR used an approach similar to the USEPA/Franklin Associates method to estimate the composition of MSW in Illinois for 1980 and 1986. Yard wastes and food wastes were not included in these estimates, but similar trends were found. The listing in Table 4.2 is the overall findings of this DENR analysis.

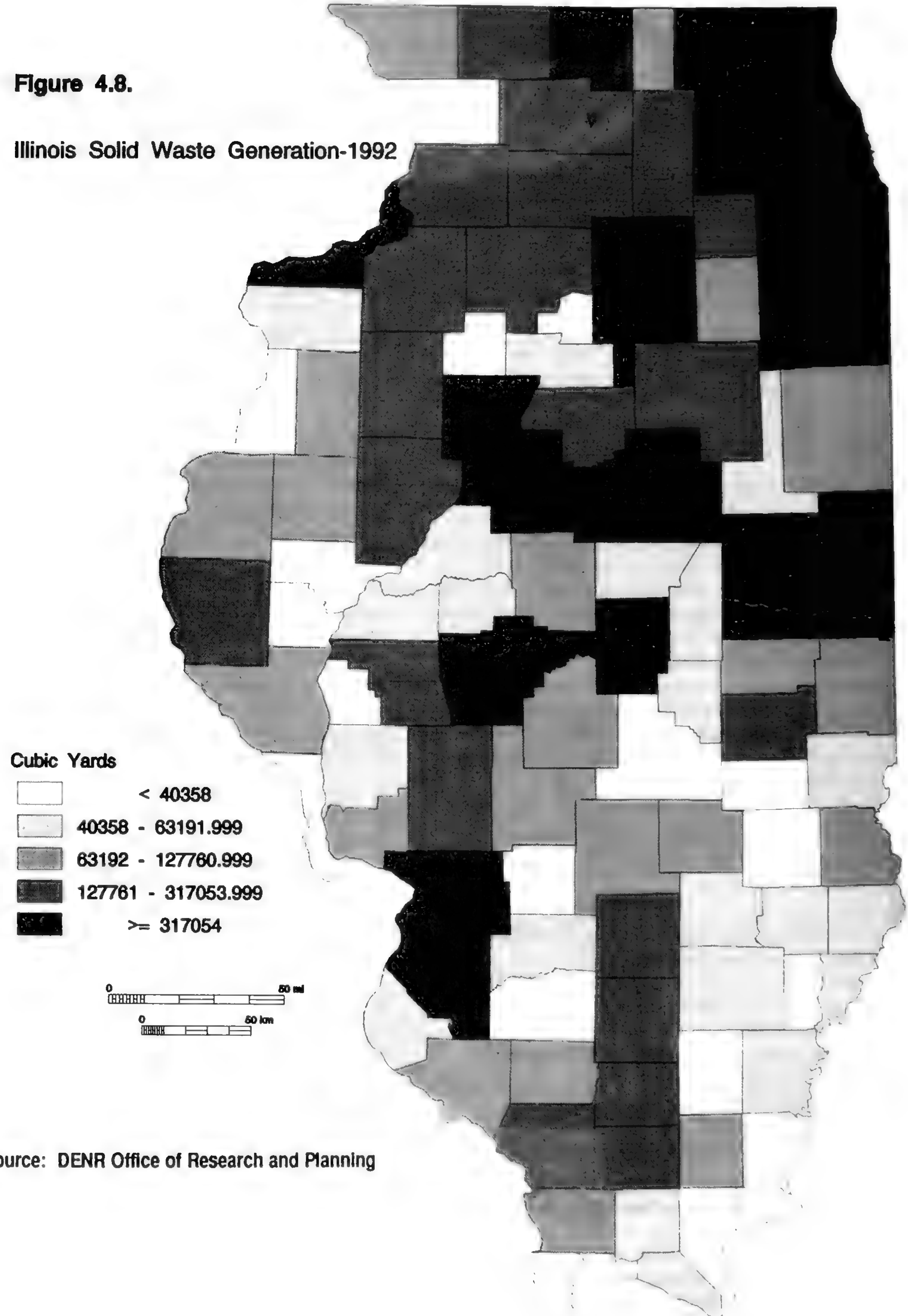
Table 4.2 Composition of MSW in Illinois

Waste Type	1980 tons	1986 tons
Newspapers	521,768	620,851
Office Paper	120,034	214,417
Total Non-Durable Paper	1,324,527	1,648,075
Corrugated Boxes	885,528	1,023,045
Total Paper Packaging	1,325,599	1,483,294
Aluminum Packaging	63,513	80,136
Steel Packaging	180,182	135,827
Total Glass Containers	697,758	565,835
Total Rigid Plastic Containers	104,093	137,753
Total All Plastic Packaging	211,144	271,703

Source: Illinois DENR, 1989.

Figure 4.8.

Illinois Solid Waste Generation-1992



Source: DENR Office of Research and Planning

The amount of paper and plastics in the waste stream increased between 1980 and 1988 while the proportion of glass and metals decreased.

Like many states, Illinois is very dependent on landfill disposal of solid wastes. The IEPA reported that over 12 million tons of waste was landfilled between April 1, 1991 and March 31, 1992. In contrast, about 225,000 tons were incinerated at the Chicago Northwest Incinerator, the only nonhazardous solid waste incinerator in operation in Illinois.

On July 1, 1990, landscape waste was banned from Illinois landfills. Many communities have established landscape waste composting sites. Approximately 418,300 tons of landscape waste were accepted at 83 of the 109 permitted composting sites between April 1, 1991, and April 1, 1992. This amount represents an 89% increase from the prior year's reported amount.

Recycling of solid wastes is another means of diverting waste from landfills. For 1992, 41% of Illinois recycling facilities responded to a survey and reported managing 1,182,225 tons. Information about the remaining 59% of Illinois recycling facilities is not available.

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HAZARDOUS WASTE

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Hazardous waste is defined by the Illinois Environmental Protection Act (Ill. Comp. Stat 1992 415 ILCS 5/3.20) as follows:

> "Hazardous Waste" means a waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible, illness; or pose a substantial present or potential hazard to human health and the environment when improperly treated, stored, transported or disposed of, or otherwise managed, and which has been identified, by characteristics or listing, as hazardous pursuant to Section 3001 of the Resource Conservation and Recovery Act (RCRA) of 1976, P.L. 94-580, or pursuant to Board regulations.

The Federal Resource Conservation and Recovery Act of 1976 (RCRA) directed the United States Environmental Protection Agency (USEPA) to set national standards for state hazardous waste programs. RCRA gave USEPA the authority to identify hazardous wastes, create a waste tracking system, and set operating standards and issue permits for treatment, storage and disposal facilities. A state hazardous waste program must adopt USEPA's standards as a minimum. Illinois' program for hazardous waste management meets the federal standards but requires more frequent reporting.

Based on USEPA's regulations, hazardous wastes are identified by two broad categories: characteristic hazardous wastes and listed hazardous wastes. Characteristic hazardous wastes exhibit one or more of the properties:

1) Ignitability: Waste posing fire hazard during routine handling;

2) Corrosivity: Wastes that could corrode their containers or leach out other waste constituents;

3) Reactivity: Unstable wastes that could react violently, explode, or generate dangerous gases;

4) Toxicity: Wastes that when tested using the Toxicity Characteristic Leaching Procedure (TCLP) demonstrate greater than specified levels of certain metals or pesticides. In 1990, TCLP replaced the extraction procedure (EP) as the method for identifying characteristically toxic hazardous wastes.

Listed hazardous wastes are identified by the fact that they are specifically named in the USEPA regulations. Several hundred chemicals and waste streams are known as listed hazardous wastes. They may come from non-specific sources, specific sources or from discarded commercial chemicals, off-specification products, and their spills and spill residues. Changes are made to the lists as additional information becomes available on wastes and their characteristics. New wastes were added to the list in 1986, 1988 and 1989 (IEPA/LPC/92-052, 1992).

While the regulatory definition of hazardous wastes is detailed, it does not include all wastes produced by industry that have potentially toxic effects. Some types of waste are exempt from hazardous waste regulation including: materials in domestic sewage, industrial discharges regulated under the Clean Water Act, gas and oil drilling production wastes, fly ash and bottom ash from burning of fossil fuels, cement kiln dust, household hazardous wastes, and agriculture wastes used as fertilizers. Other wastes are regulated under acts different from RCRA but may be subject to RCRA regulations if mixed with RCRA wastes. For example, spent nuclear materials and PCBs are regulated by acts other than RCRA but are reflected in hazardous waste reporting when combined with hazardous wastes. Additionally, the CAAA of 1990 listed approximately 200 specific chemicals as Hazardous Air Pollutants and the Illinois Pollution Control Board listed over 200 chemicals as Illinois Air Toxic Contaminants. These chemicals may not fall into the specific definition of "hazardous waste" but have the potential to be harmful to human health and the environment.

An estimation of the volume of hazardous wastes generated and managed is possible as the result of USEPA reporting requirements. RCRA and Illinois hazardous waste regulations require generators and permitted treatment, storage, disposal and recovery (TSDR) facilities to submit reports summarizing hazardous waste activities. The reports, submitted by March 1, contain information about the previous calendar year. The annual reports identify the type of wastes received or shipped, quantity of wastes, and the method of management for each waste. USEPA requires biennial reporting while IEPA maintains a stricter requirement of annual reporting. The annual report requirement became effective in 1983, summarizing activities for the 1982 calendar year.

Hazardous waste from "conditionally exempt" and "small quantity generators" (SQGs)are regulated in much the same fashion as large quantity generators but are not subject to the same reporting requirements. Conditionally exempt generators are those who generate less than 100 kg per month of hazardous waste or less than 1 kg per month of acutely hazardous waste. SQGs are those generators who generate between 100 kg and 1000 kg per month of hazardous wastes. These two types of generators are not required to submit annual hazardous waste reports. SQG wastes are reflected in Illinois TSDR facility reporting.

The hazardous waste annual reports are a significant component of Illinois' hazardous waste regulatory program (IEPA/LPC/92-052, 1992). Information gathered through the annual reporting requirement is used to identify trends, project capacity needs and for planning regulatory programs. This discussion of hazardous wastes in Illinois, will consider only those wastes defined as hazardous and reflected in Illinois reporting.

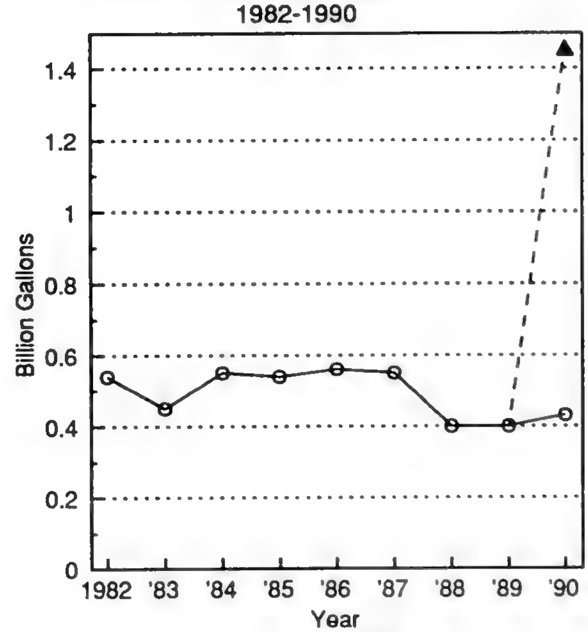
HAZARDOUS WASTE GENERATED IN ILLINOIS

IEPA has estimated the volume of hazardous waste generated in the state using the annual hazardous waste reports. The reported volume of imports to Illinois is subtracted from the total reported volume of hazardous waste managed in the state; the result is added to the reported volume of waste exported to other states to obtain an accurate estimate of the volume of hazardous wastes generated by Illinois' industry. Waste that was managed in long-term storage facilities or transfer sites is not included to avoid double counting (IEPA/LPC/92-052, 1992).

In 1990, the total reported quantity of hazardous waste generated in Illinois was 6.23 million tons. This represented a dramatic increase from the volume generated in 1989. This huge increase in generation (1.74 million tons to 6.23 million tons) was the result of the regulatory change in 1990 requiring the TCLP toxicity test for identifying characteristically hazardous waste. A waste generated by two refineries accounted for 85% of the total volume generated (IEPA/LPC/92-052, 1992). This waste stream had been generated for years at these oil refineries but was not defined as hazardous until TCLP was the required test for toxicity. If this one waste is not included, the adjusted generation volume would be 1.93 million tons, representing a 10.7% increase from the 1989 reported volume. This large fluctuation in reported volume demonstrates the fact that regulatory changes and revisions of the definition of hazardous waste can have a large impact on the state's estimates of hazardous waste generation and management.

Figure 5.1 displays the amount of hazardous waste (in gallons) generated in Illinois since 1982 as reported by IEPA (gallons rather than tons were used to keep prior years comparable).

Hazardous Waste Generated in Illinois
1982-1990



O in 1990 is quantity of waste generated without the newly-regulated oil refinery waste

▲ represents quantity of hazardous waste generated in 1990 including newly-regulated oil refinery waste

Source: Summary of Annual Reports on Hazardous Waste; IEPA/LPC/92-052

Figure 5.1

Number of Hazardous Waste Generators in Illinois

Generators of hazardous waste are those companies or entities that produce regulatorily-defined hazardous wastes. Not all Illinois companies are hazardous waste generators. Smaller companies may be considered SQG's. Other firms produce wastes which are not considered hazardous and are thus not subject to RCRA regulations. A generator may manage it's hazardous waste on-site or ship it off-site for commercial management in Illinois or out-of-state. Generator annual reports are submitted only by companies that produce hazardous wastes and then ship them off-site for management. Generators who manage their wastes on-site are considered to be regulated TSDR facilities and must report the types and quantities of hazardous waste managed. During 1990, IEPA received 2329 generator reports of which 1477 were from fully regulated generators. The remaining 852 were submitted by companies which indicated that no hazardous wastes were generated during the year, were classified as SQG's, or were not subject to reporting due to closure or other means. Figure 5.2 shows the number of fully regulated generators submitting generator reports to IEPA since 1982. IEPA attributes the 1985 increase to regulatory changes which expanded the reporting universe to include generators that shipped solvents to reclamation facilities.

In 1990, IEPA reported only 5 generators which manage all of their wastes on-site, down from a high of 111 generators in 1982.

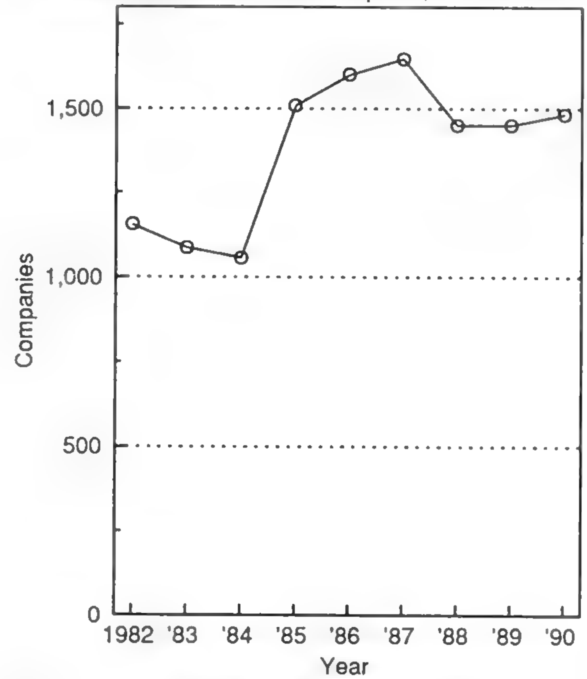
While the hazardous waste regulations and reporting system are applicable to over 1000 companies in Illinois, not every Illinois company or manufacturing facility is subject to hazardous waste regulations because of the quantities or types of waste produced. The 1992 Harris Illinois Industrial Directory, published in cooperation with the Illinois State Chamber of Commerce listed 21,769 manufacturing facilities in Illinois. Many manufacturers may not be subject to RCRA regulations but other kinds of environmental regulations may apply.

Largest Hazardous Waste Generators in Illinois

Generators Who Ship Waste Off-Site

During 1990, there were 18 generators that reported shipments of more than 5,000 tons of hazardous waste to off-site management facilities. These 18

Number of Fully Regulated Generators Submitting Annual Hazardous Waste Reports, 1982-1990



Source: Summary of Annual Reports on Hazardous Waste; IEPA/LPC/92-052

Figure 5.2

facilities are located in only 7 different counties: Cook, Grundy, Kankakee, Madison, Peoria, St. Clair and Will. Together, these facilities generate 49.9% of all hazardous wastes shipped off-site in 1990. Table 5.1 lists the 1990 generators who shipped more than 5,000 tons of waste off-site.

Generators Who Manage Waste On-Site

The IEPA has identified the on-site facilities that manage more than 5,000 tons of wastes. These are dominated by two facilities (oil refineries) that manage over 4 million tons of hazardous wastes on-site. The volume of wastes generated and managed at on-site facilities far outweighs the volume of wastes generated at Illinois facilities and then shipped to off-site management facilities. Of the 6.23 million tons of waste generated in Illinois during 1990, 89.9% was generated by companies that are able to manage these wastes on-site. Table 5.2 lists the 13 generators identified by IEPA managing more than 5,000 tons of hazardous wastes on-site (comparable to 1 million gallons waste with average density of 10 lbs per gallon). The waste generated at these 13 facilities accounts for 95.6% of all waste generated and managed on-site, and 88% of all total waste generated in Illinois.

Table 5.1. 1990 Hazardous Waste Generators Shipping More Than 1 Million Gallons Off-Site

Company	Tons Shipped	% Total Shipped
Safety Kleen, Dolton (secondary waste*)	33,427	6.8
US Steel, Chicago	23,193	4.7
Harcos Chemical, Chicago (cleanup)	22,952	4.7
Cerro Copper Products, Sauget (cleanup)	21,884	4.4
Mobil Oil Corp, Joliet	16,208	3.3
Trade Waste Incineration, Sauget (secondary waste)	15,784	3.2
Environmental Waste Resources, Coal City (secondary waste)	15,035	3.1
Flintkote, Chicago Heights (cleanup)	12,762	2.6
Keystone Steel and Wire, Peoria	11,443	2.3
Republic Engineered Steel, Chicago	8,601	1.7
Nutrasweet, University Park	7,805	1.6
The Steel Co, Chicago	6,874	1.4
Shell Oil Co, Roxana	6,811	1.4
Shell Oil, Bedford Park	6,505	1.3
CWM Chemical Services, Chicago (secondary waste)	6,242	1.3
Olin Corp, East Alton	6,156	1.2
Cook County (cleanup), Chicago	5,737	1.2
Birmingham Bolt, Chicago	5,679	1.2

* Secondary Waste results from the treatment of primary wastes prior to ultimate disposal. Some treatment methods can increase the waste quantity.

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Hazardous Waste Generation By County

Generators Who Ship Waste Off-Site

Of the 102 counties in Illinois, firms in 78 generated some volume of hazardous wastes that were shipped off-site for management. Cook County generators have consistently produced the highest volume of hazardous wastes that are shipped off-site for management, accounting for 48.5% of all 1990 wastes shipped off-site during 1990. The six counties in the Chicago metropolitan area (Cook, DuPage, Lake, Kane, McHenry, and Will) combined, generated 64.9% of the hazardous wastes shipped off-site in 1990.

In a few counties, a disproportionate amount of wastes were shipped off-site relative to the number of regulated generators. In Lake County, 4.2% of the generators shipped only 1.4% of the wastes suggesting that many of the generators are of a smaller than average size. Kane, DuPage and McHenry counties show a similar pattern. On the other hand, St. Clair county generators ship a disproportionately large volume of waste relative to the number of generators. This suggests the volume of wastes generated and shipped at each St. Clair county facility is greater than average. Figure 5.3 displays the number of regulated hazardous waste generators by county and demonstrates the heavy concentration in the Chicago Metropolitan Area.

Figure 5.3

Number of Hazardous Waste Generators by County, 1990

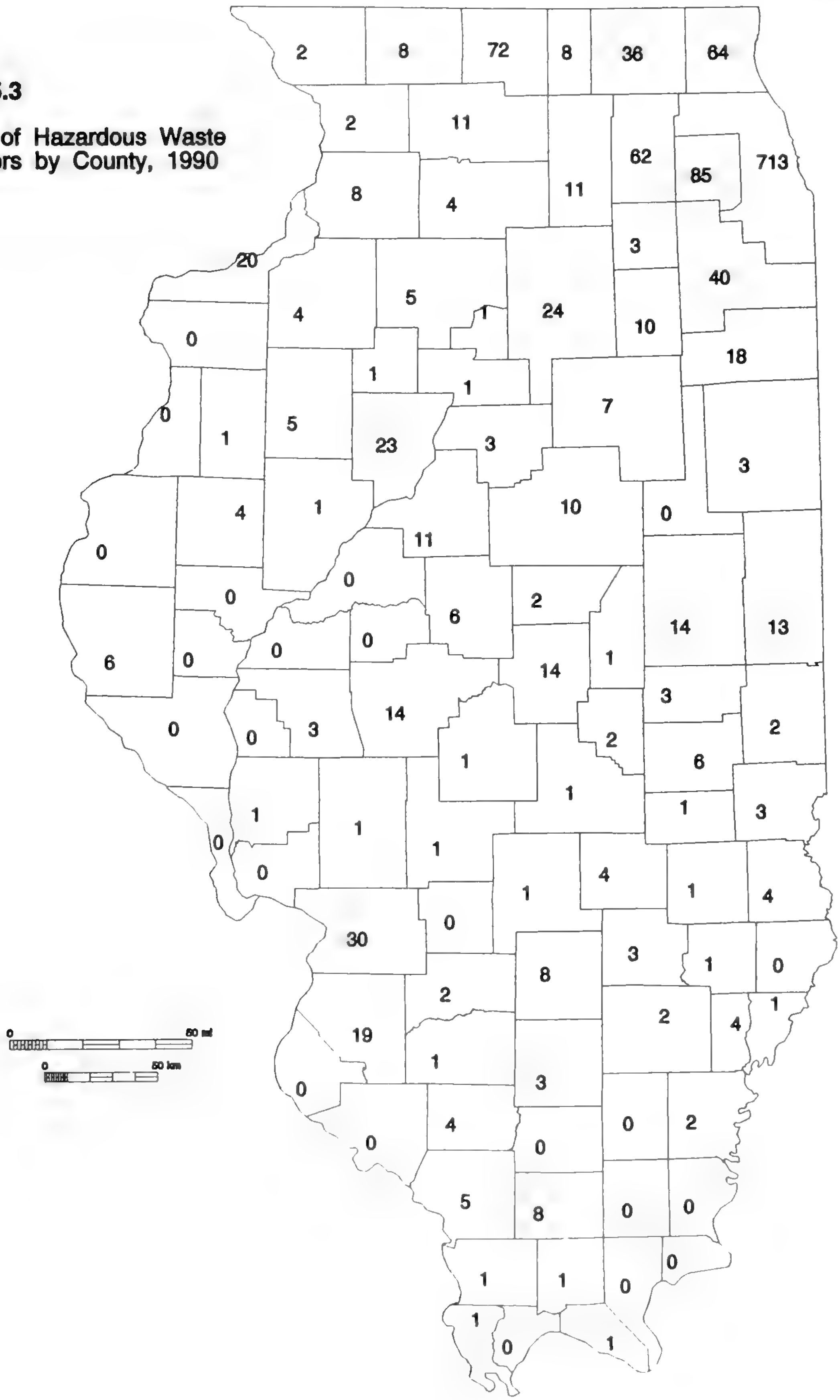


Table 5.2. 1990 Hazardous Waste Generators Managing More Than 5,000 Tons Waste On-Site

Company	Tons	% Total
Shell Oil, Roxanna	3,211,080	54.7
Marathon Oil, Robinson	1,096,536	18.7
Allied Signal, Metropolis	432,419	7.4
Cabot Corporation, Tuscola	394,672	6.7
Amoco, Wood River	66,660	1.1
Chemetco, Hartford	65,000	1.1
Allied Signal, Danville	62,009	1.1
Northwestern Steel and Wire, Sterling	46,490	0.8
Olin Main Plant, East Alton	40,112	0.7
LTV Steel, Hennepin	36,066	0.6
CCL Custom Mfg, Danville	17,261	0.3
Laclede Steel, Alton	13,424	0.2
National Maintenance and Repair, Hartford	5,387	0.1

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Generators Who Manage Wastes On-Site

Only 41 of the 102 Illinois counties are home to generators managing hazardous waste on-site. During 1990, a total of 5.87 million tons of waste were generated and managed on-site in Illinois; over 3.4 million tons were in Madison county and 1.1 million in Crawford county. Much of the on-site disposal reflects the addition of oil refining TCLP toxic waste to the list of regulated wastes. This change made Madison and Crawford counties the largest producers of hazardous wastes managed on-site. Prior to 1990, Clark, Douglas and Massac counties contributed the largest volumes of waste managed on-site. Table 5.3 lists the counties in which generators manage wastes on-site and the tons managed in 1990.

Figures 5.4 and 5.5 represent the total hazardous waste generated by county and the total volume of hazardous waste managed by county in 1990. A comparison of these maps reveals that wastes in Illinois are not always managed in the same county in which they are generated. Due to the location of hazardous waste management facilities, management of hazardous waste is concentrated in specific geographic area of the state to a greater extent than hazardous waste generation.

Hazardous Waste Generation by Industry Group

Research projects funded by HWRIC and others have helped describe the industrial mix of hazardous waste generators in Illinois.

In 1986, HWRIC contracted with the Center for Economics Research at the Research Triangle Institute (RTI) to analyze Illinois data collected as part of the USEPA generator and TSDR survey for hazardous wastes. The 1986 data represented the most current data about generation and management of hazardous wastes in all 50 states. The Illinois analysis provided a profile of hazardous waste generating industries a characterization of the wastes and identified differences between Illinois and the nation as a whole.

RTI found that in Illinois, the largest generators of hazardous wastes in 1986 were metal-related industries like primary metals manufacturers or metal fabricators. In contrast, the largest hazardous waste generators in most other states were identified to be the chemical, electronic components and petroleum

Table 5.3. Illinois Counties with Hazardous Wastes Managed On-Site

County	Tons Waste	County	Tons Waste
Carroll	61	McHenry	2,149
Champaign	15	McLean	159
Clark	212,384	Macon	22
Coles	13	Madison	3,405,699
Cook	68,677	Massac	432,419
Crawford	1,096,536	Morgan	355
DeKalb	11	Ogle	1,119
De Witt	5	Peoria	72,717
Douglas	394,672	Putnam	36,066
DuPage	3,992	Rock Island	1,405
Grundy	105	St. Clair	1,094
Jackson	3,423	Stephenson	3,121
Jefferson	69	Tazewell	45
JoDaviess	22	Union	49
Kane	264	Vermillion	79,280
Kankakee	4,882	Whiteside	46,498
Kendall	69	Will	2,052
Lake	1,719	Williamson	39
Lasalle	1,485	Winnebago	102
Logan	222		

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

industries. The RTI study identified SIC 3312, Blast Furnaces and Steel Mills, to be the largest contributor of hazardous waste in Illinois, accounting for 29.3% of the estimated volume generated. The study also identified SIC 3482, Small Arms Ammunition, SIC 3429, Hardware, nec, SIC 3531, Construction Machinery, and SIC 3471 Plating and Polishing to be significant contributors of hazardous waste in the state. Figure 5.6 displays the relative contribution of these different industry groups.

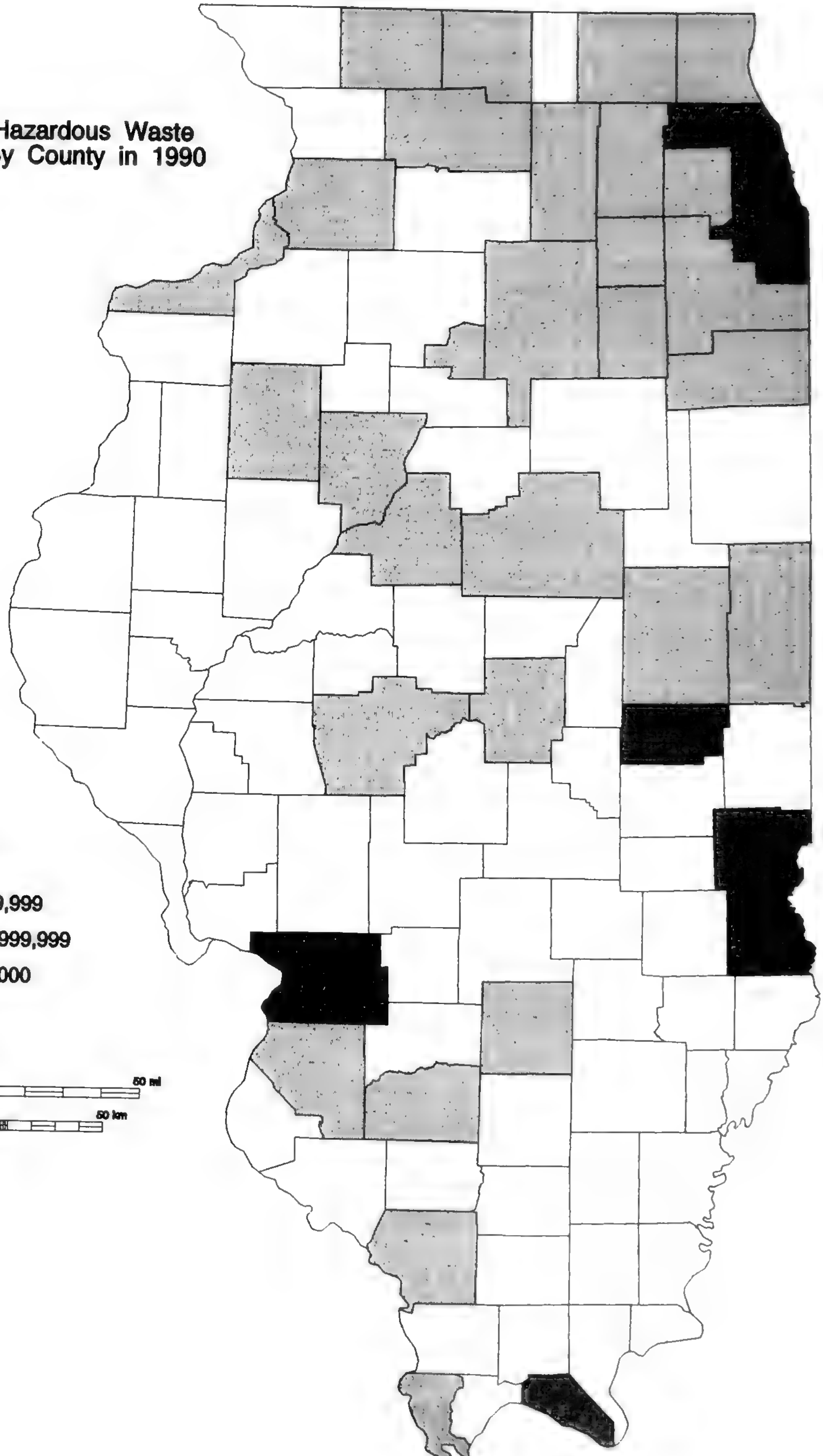
RTI also evaluated the number of hazardous waste generators from each industry group. Of the 864 large quantity generators surveyed in the study, the largest number, 69, represented SIC 3471, Plating and Polishing. Sixty-five generators represented SIC 2851, Paints and Allied Products. The remaining 730 generators represented all other industry groups doing business in Illinois (Figure 5.7).

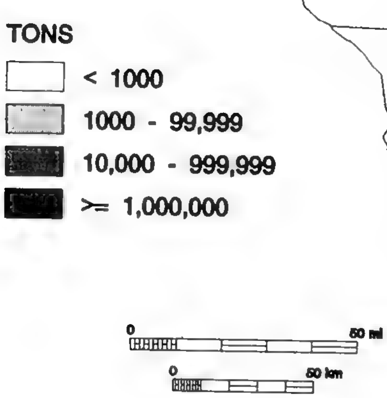
HWRIC conducted a similar analysis of hazardous waste-generating industries for 1990 using information from the annual hazardous waste report. The RTI analysis used a slightly different universe of hazardous wastes than are included as part of the Illinois annual hazardous waste reporting system making direct comparisons difficult. However, some overall trends may be observed by comparing the two analyses.

Using computerized database files, printed reports, industrial directories and other sources, industrial categories and associated volumes of generated hazardous waste were estimated for 1990. This analysis considered wastes disposed on-site and wastes shipped to Illinois commercial facilities.

Figure 5.4.

Total Tons Hazardous Waste Generated By County in 1990





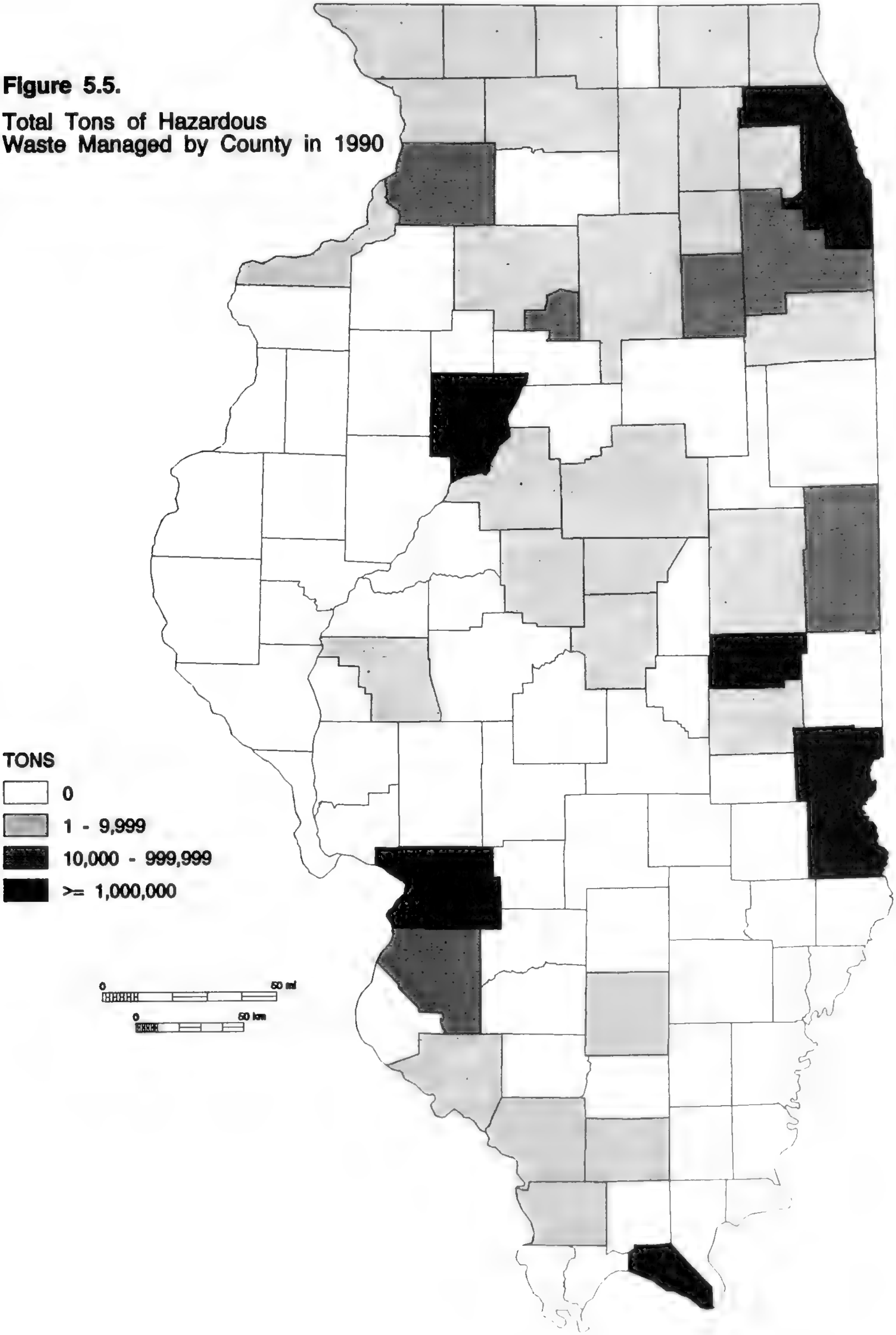
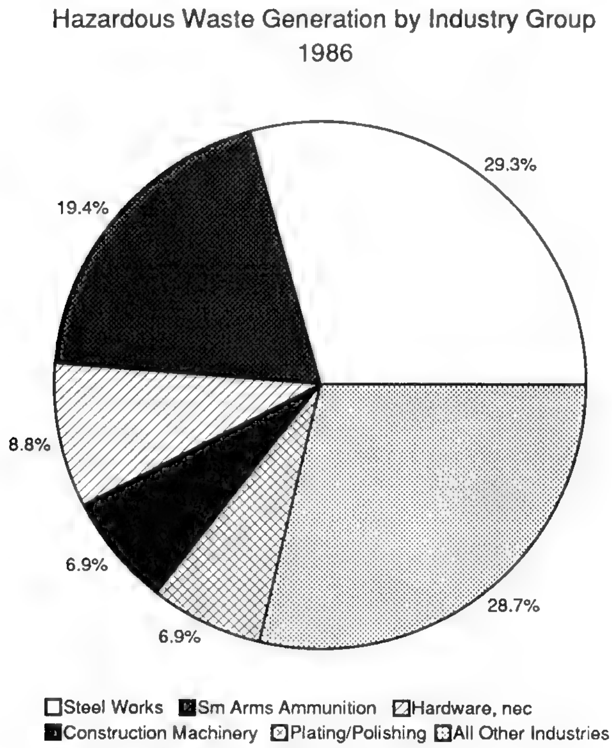
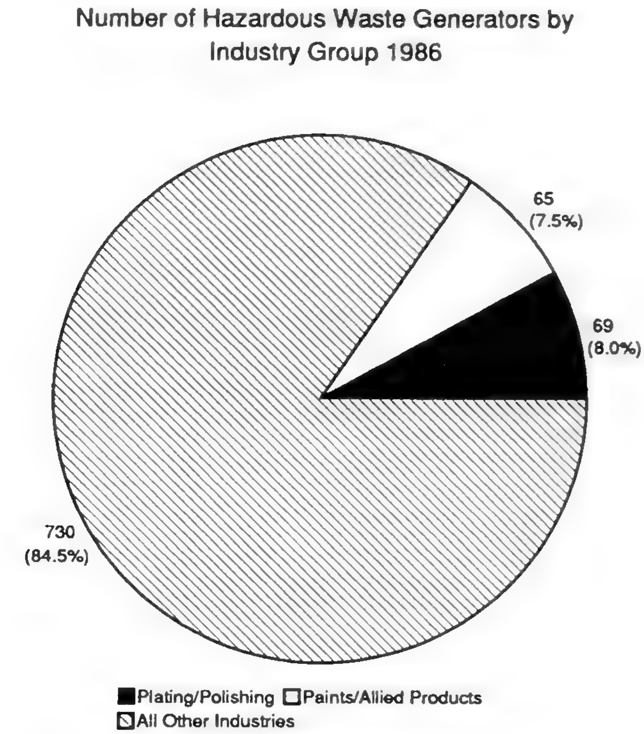


Figure 5.5.
Total Tons of Hazardous Waste Managed by County in 1990



Source: Generation and Management of Hazardous Waste in Illinois During 1986, RTI

Figure 5.6



Source: Generation and Management of Hazardous Waste in Illinois During 1986, RTI

Figure 5.7

The HWRIC analysis found the petroleum refining industry to contribute the largest volume of hazardous wastes in the state, over 4.4 million tons; this is not surprising considering the regulatory change to TCLP data. The industrial inorganic chemical industry, SIC 2819, was found to be the second largest generating industry with 0.83 million tons of waste. Table 5.4 lists the ten industries generating the largest volumes of hazardous waste based on the HWRIC analysis.

Large volumes of hazardous wastes are generated by SIC 4953, Refuse Systems, and SIC 7389, Business Services, nec, includes solvent recovery services. The wastes produced by these industry groups are likely to be secondary wastes produced as a result of a treatment or recovery process or from the cleanup of contaminated sites. For the purposes of this analysis, primary hazardous waste generation was assumed to approximate total generation less the volume produced by refuse systems and business services.

The oil refining industry dominates the industrial profile of primary wastes generated in Illinois contributing over 80% of the total (see Figure 5.8). Subtracting the two largest oil refineries, for the sake of comparison, industrial inorganic chemicals, steel works and other petroleum refining are shown to be the largest contributors to Illinois hazardous waste generation (see Figure 5.9). The steel works and small arms ammunition industries appear as significant contributors in both the RTI and HWRIC analyses.

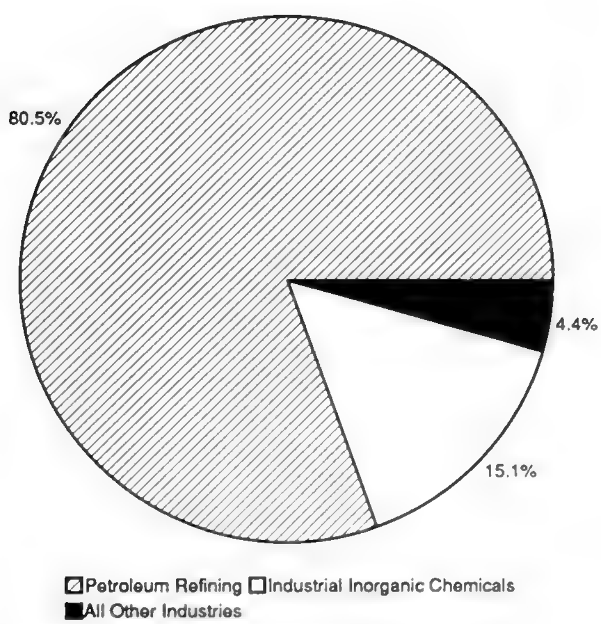
The effect of regulatory changes on reported volumes of waste generated have been discussed above. These same changes also affect the industries subject to regulation. A comparison of the RTI (1986) and HWRIC (1990) industry profiles demonstrates how significant changes in regulation can be.

Table 5.4. Top 10 Hazardous Waste Generating Industries 1990

SIC	Industry Description	Tons Generated
2911	Petroleum Refining	4,410,080
2819	Industrial Inorganic Chemicals, nec	827,536
3312	Steel Works, Blast Furnaces, and Rolling Mills	145,016
4953	Refuse Systems	131,296
2869	Industrial Organic Chemicals, nec	94,008
3341	Secondary NonFerrous Metals	89,498
7389	Business Services, nec	48,061
3482	Small Arms Ammunition	46,366
2821	Plastics Materials and Resins	23,255
2844	Perfumes, Cosmetics, Toilet Preparations	17,610

Source: HWRIC, 1993.

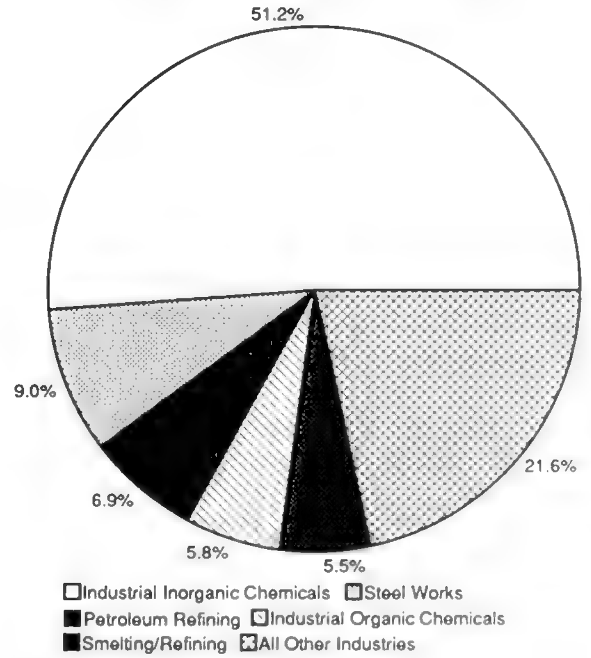
Estimated Primary Hazardous Wastes Generated in Illinois 1990 by Industry



Source: 1993 HWRIC Analysis

Figure 5.8

Estimated Primary Hazardous Wastes Generated in Illinois 1990 by Industry Not Including 2 Large Oil Refineries



Source: 1993 HWRIC Analysis

Figure 5.9

Types of Hazardous Waste Generated in Illinois

The 1990 annual hazardous waste report provided information about generation classified into 17 waste types. These waste types are different from traditional RCRA waste types and are based on the physical and chemical properties of the waste. These waste type categories are also used in production of the State Capacity Assurance Plan (CAP), are simpler to use and easier to understand than the customary RCRA codes. Table 5.5 lists the waste types now used to characterize Illinois hazardous wastes (a more detailed definition of each is found in Appendix 5.1).

Most of the waste generated in 1990 was of the type, "Inorganic Liquids with Organics," accounting for 4.5 million of the 6.2 million tons of hazardous waste generated as reported by IEPA. Virtually all of this inorganic liquids with organics waste consists of the oil refinery waste added to the regulatory system in 1990 (4.3 of 4.5 million tons). Table 5.6 lists the 17 waste types, tons of each type generated in 1990, and the net change since 1987 (1987 data obtained from Capacity Assurance Plan, 1989). Inorganic liquids with metals and inorganic liquids (nec) account for large portions of the Illinois hazardous waste generation with over 1.5 million tons.

A comparison of 1987 data with the 1990 information revealed the largest increases in volume were found in the inorganic liquids, inorganic sludges and solids with metals, and contaminated soils categories. There are many possible explanation for these increases. Changes in regulation involving underground storage tanks and the cleanup of leaking sites are likely to have contributed to the increase in the contaminated soil category.

HAZARDOUS WASTE MANAGED IN ILLINOIS

In 1990, IEPA reported that the total quantity of RCRA hazardous wastes managed in the state to be 6.4 million tons. Figure 5.10 shows the quantity of waste reported to be managed in the state since 1982.

Quantity is provided in gallons to allow for comparison with prior years. Not surprisingly, the addition of the TCLP requirement created a substantial increase in the amount of hazardous wastes reported to be managed in Illinois. Without the large oil refining waste streams, the quantity managed in the state, at on-site facilities and commercial sites has remained fairly constant.

Of the 6.4 million tons managed in 1990, 5.7 million tons were managed on the site of generation. Much of this is managed at two large oil refineries but even prior to 1990, a substantial portion of hazardous wastes managed in the state was managed on-site (Table 5.7).

The management of hazardous waste on-site is not a new phenomenon. It is believed that prior to environmental regulations, most, if not all, hazardous wastes were disposed at the site of generation. On-site management volumes of industrial wastes (hazardous and nonhazardous) have surpassed commercial management volumes ever since such information has been gathered for the state.

Number of Hazardous Waste Management Facilities

The number of facilities permitted to manage RCRA hazardous wastes has dropped significantly since the advent of regulation. In 1982 there were over 300 facilities managing hazardous wastes; in 1990 only 152 were permitted (see Figure 5.11). This decrease in the number of permitted facilities occurred during a time when management volumes remained fairly constant, suggesting an increasing management volume per facility.

Only five of the 152 active facilities in 1990 are regulated generators managing all wastes on-site. As requirements for RCRA facilities have been implemented, the number of generators disposing all wastes on-site has declined, but the volumes of wastes managed on-site remain significant.

Management Methods Used in Illinois

Hazardous wastes can be managed using a variety of different methods. Each method has a unique set of operating procedures, permit requirements and applicable waste types. Management methods for hazardous wastes have been classified into the following types: treatment and recycling, injection wells, surface impoundments, landfills, storage, incineration and land treatment.

During 1990, the majority of the hazardous wastes managed in Illinois were oil refining wastes. A treatment process is used to manage these wastes. A profile of management methods used in Illinois will

Table 5.5. 17 Waste Types Used to Categorize Hazardous Waste

Contaminated Sand Soil and Clay	Halogenated Solvents	Nonhalogenated Solvents
Halogenated Organic Liquids	Nonhalogenated Organic Liquids	Organic Liquids, Unspecified
Mixed Organic and Inorganic Liquids	Inorganic Liquids with Organics	Inorganic Liquids with Metals
Inorganic Liquids, NEC	Halogenated Organic Sludges and Solids	Nonhalogenated Organic Sludges and Solids
Organic Sludges and Solids, Unspecified	Mixed Organic and Inorganic Sludges and Solids	Inorganic Sludges and Solids with Metals
Inorganic Sludges and Solids, NEC	Other Wastes	

Source: Summary of Annual Reports on Hazardous Waste; IEPA/LPC/92-052.

Table 5.6. Hazardous Waste Generated By Waste Type

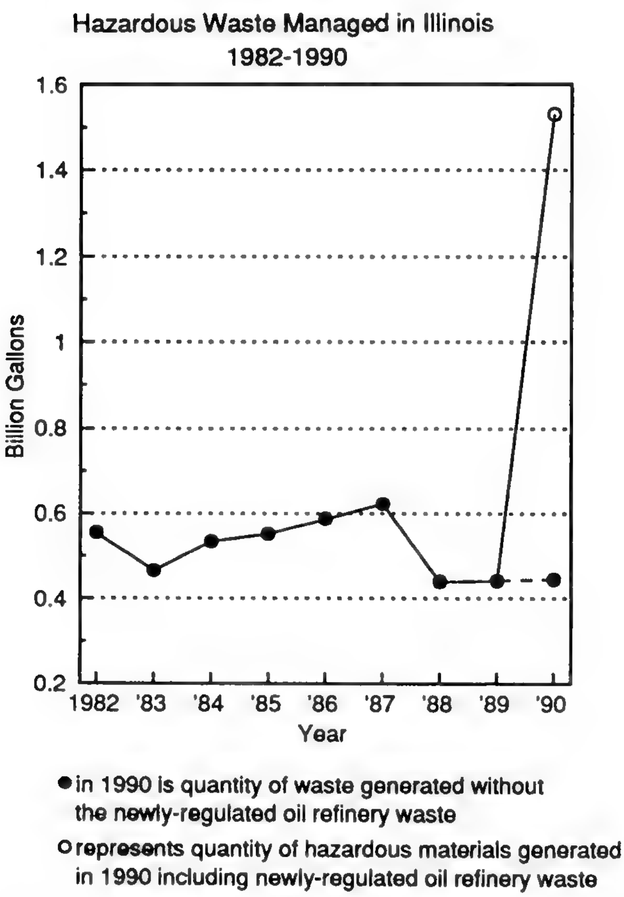
Waste Type	1990	% Total	(+/-) since 87
Contaminated Sand Soil and Clay	105,574	1.7	79,178
Halogenated Solvents	20,356	0.3	(3,783)
Nonhalogenated Solvents	67,131	1.1	41,403
Halogenated Organic Liquids	11,176	0.2	(1,725)
Nonhalogenated Organic Liquids	29,227	0.5	7,907
Organic Liquids, Unspecified	10,627	0.2	10,594
Mixed Organic and Inorganic Liquids	23,102	0.4	(177,725)
Inorganic Liquids with Organics	4,511,973	72.4	4,480,900
Inorganic liquids with Metals	531,946	8.5	50,412
Inorganic Liquids, Not Elsewhere Classified (nec)	526,965	8.5	9,770
Halogenated Organic Sludges and Solids	20,361	0.3	15,106
Nonhalogenated Organic Sludges and Solids	8,989	0.1	(258,059)
Organic Sludges and Solids, Unspecified	4,142	0.1	(59)
Mixed Organic and Inorganic Sludges and Solids	25,876	0.4	(77,006)
Inorganic Sludges and Solids With Metals	323,866	5.2	157,620
Inorganic Sludges and Solids nec	4,914	0.1	4,885
Other Wastes	2,851	0.0	(1,962)

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

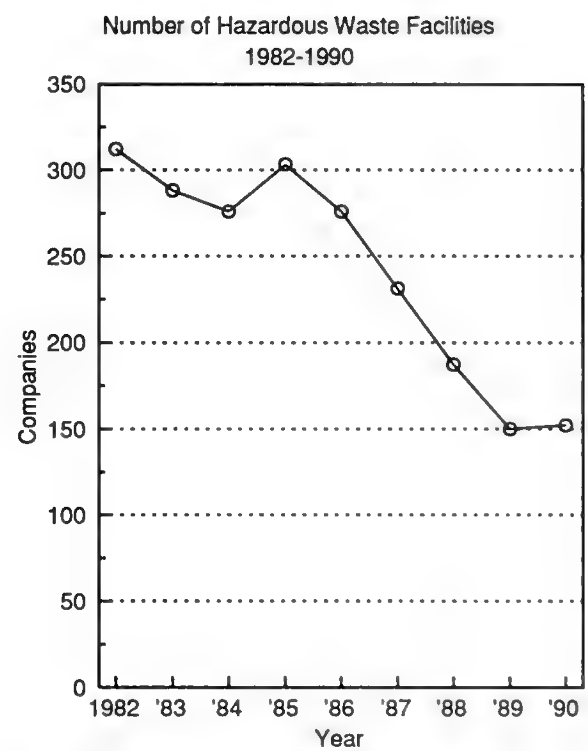
Table 5.7. Management of Hazardous Waste in Illinois 1988-1990

	1988	1989	1990
Managed On-Site	1,322,775	1,489,403	5,742,039
Managed Off-Site and Generated in Illinois	256,960	236,169	335,408
Managed Off-Site and Generated Out-of-State (Imports)	239,469	283,496	335,142
Total Management in Illinois	1,819,204	2,009,068	6,412,589

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.



Source: Summary of Annual Reports on Hazardous Waste; IEPA/LPC/92-052.
Figure 5.10



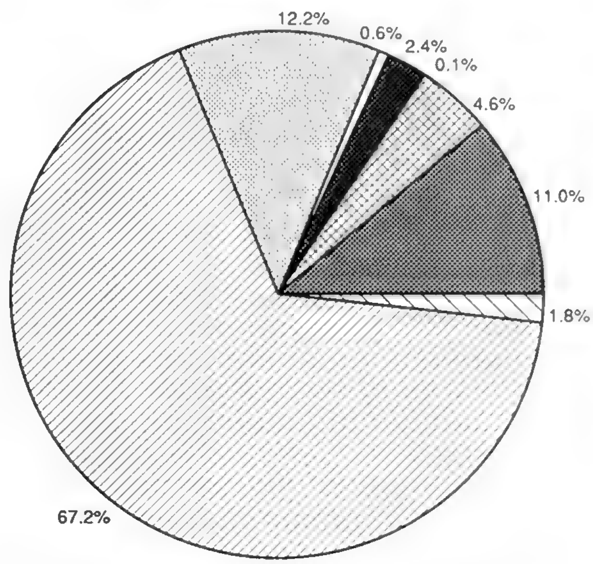
Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052
Figure 5.11

be skewed by the method used for oil refining wastes.

Figure 5.12 demonstrates this effect as oil refinery treatment accounts for 67.2% of wastes managed. Other than oil refining treatment, Illinois was dependent on the use of injection wells, landfills and treatment/recovery methods for the management of hazardous wastes in 1990.

There was little change in the relative use of different methods for managing hazardous waste in Illinois from 1982 - 1990. Figures 5.13 and 5.14 breakdown the volume of hazardous waste managed in the state by management method for every year since 1982. Figure 5.13 displays information for years 1982-1988 on a gallon basis. Figure 5.14 includes years 1988-1990 based on total tons. For each year, treatment and recycling, injection wells, and landfills are used often. Surface impoundment use has fluctuated more than the other management methods, likely due to changes in regulation.

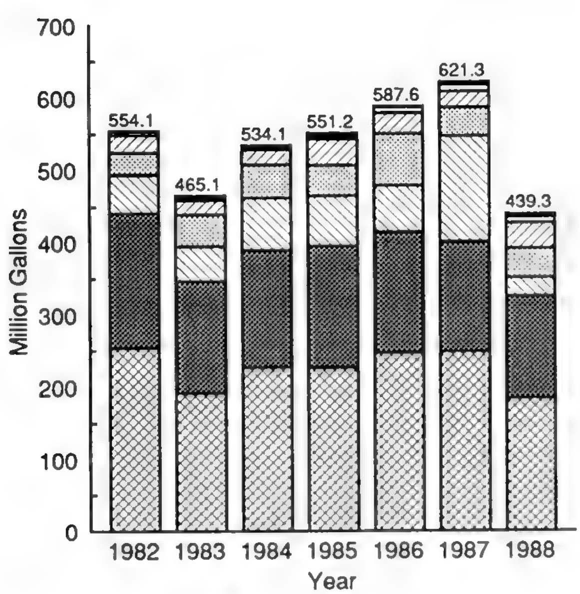
Hazardous Waste Management Methods 1990
Based on Total Tons Managed



Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Figure 5.12

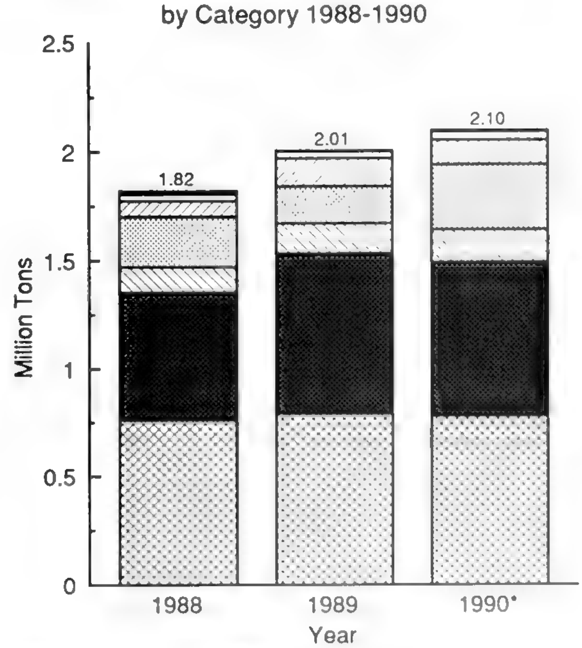
Hazardous Waste Management in Illinois
by Category 1982-1988



Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Figure 5.13

Hazardous Waste Management in Illinois
by Category 1988-1990



*1990 waste total does not include oil refining waste

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052

Figure 5.14

Table 5.8 Projected Capacity For Commercial Hazardous Waste Management in Illinois

Management Category	1989 Capacity (tons)	1995 Capacity (tons)	2009 Capacity (tons)
Metals Recovery	79,605	120,096	125,436
Solvent Recovery	337,372	296,599	296,274
Other Recovery	0	0	0
Incineration Liquids	31,927	42,828	43,025
Incineration Solids/Sludges	2,770	32,796	60,315
Energy Recovery	(47,106)	(22,010)	(18,733)
Aqueous Inorganic Treatment	337,629	521,931	530,511
Aqueous Organic Treatment	0	0	0
Other Treatment	1,241	1,286	1,510
Sludge Treatment	0	0	0
Stabilization	40,506	39,005	44,543
Land Treatment	0	0	0
Landfill	4,450,342	3,071,389	3,721
Deepwell Injection	0	0	0
Other Disposal	0	0	0
Total All Management Types	**5,234,286**	**4,103,920**	**1,086,602**

Source: 1989 Capacity Assurance Plan State of Illinois

CAPACITY ISSUES RELATED TO MANAGEMENT OF HAZARDOUS WASTES IN ILLINOIS

In fulfillment of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), section 104 (c) 9, states are required to demonstrate adequate capacity for the destruction, treatment, or secure disposal of all hazardous wastes expected to be generated within a 20 year time frame.

Information from 1987 was used as a base year of generation and management volumes. USEPA provided the States with guidelines to make projections for two, seven and 20 years (1989, 1995, 2009) from that base year. These guidelines included:

1) Accounting for effect of economic expansion or contraction on waste generation;
2) Projections of the effect of waste minimization efforts on generation and management activities;
3) Consideration of non-recurrent wastes (from remediation activities) and both primary and secondary waste generation; and
4) Accommodation of the potential effects that regulatory changes would have on future waste generation and management.

The first Capacity Assurance Plan (CAP), produced by IEPA in 1989, demonstrated Illinois had the capacity to manage hazardous wastes produced in the State through the year 2009 except for those wastes managed via energy recovery (Table 5.8). As discussed in the 1989 CAP, this shortfall can be met on a regional level with capacity available in Michigan, Ohio, and Wisconsin.

The 1989 CAP demonstrated Illinois' capacity for managing wastes generated in-state but did not attempt to address issues related to hazardous waste imports. Hazardous waste imports from other States contribute a significant portion of the wastes managed in Illinois; they constitute approximately half of the waste managed at Illinois commercial facilities. These wastes are generally primary wastes (imported for destruction, recovery, and/or treatment), secondary wastes produced from the treatment of primary wastes, non-recurring wastes from remedial action sites, and nonhazardous solid wastes that may go to hazardous waste landfill in Illinois. Future imports and exports may affect Illinois capacity significantly, changing the conclusions drawn in the 1989 CAP.

The projections for capacity made in the 1989 CAP will also be influenced by factors other than imports to the state. Nonhazardous waste consumes hazardous waste capacity in Illinois. In 1989, the volume of such waste was projected to be 1.5 million tons. IEPA projects that nonhazardous waste consuming hazardous waste capacity will decrease 50% by the year 1995, but any changes to that prediction may change the state's capacity needs. Applications for new hazardous waste facilities and proposed changes to existing facilities (expansions/closures) will also change the state's projections for its hazardous waste capacity needs.

IEPA is producing the second edition of the state's hazardous waste capacity demonstration. Nationwide, very little new hazardous waste TSDR capacity has been added in recent years. Illinois does not seem to have an immediate hazardous waste capacity problem today, but one could arise in the future. (The shut-down of the Chem Waste Incinerator in Chicago will certainly have an impact on the state's ability to manage hazardous wastes). The new capacity demonstration, will provide a better, more up-to-date look at the state's ability to manage wastes and help identify the issues related to capacity deserving the most attention in the future.

Management of Waste By County

In Illinois, the management of hazardous wastes does not occur uniformly throughout the state. Fewer counties manage hazardous wastes than generate such wastes. The location of those generators who manage wastes on site greatly influences the distribution of waste management in the State. Figure 5.5 displays the total volume of hazardous waste managed by county in 1990.

One would expect that the more industrial areas of the state would be managing the most hazardous wastes. This has generally been the case. A few notable exceptions exist where waste is managed at on-site facilities and where unique management techniques (like underground injection) are available.

Because Illinois has a number of hazardous waste landfills, incinerators and other treatment and reclamation facilities, the state attracts shipments of waste from other areas of the country. Illinois' commercial hazardous waste management business is dependent on imports from other states. The CAP demonstrated to IEPA the need to account for the effects of secondary waste, with respect to imports. In some cases, management practices result in larger volumes but decreased hazard of a particular waste. The reported volume of wastes imported to Illinois does not take into account the volume effect some treatment processes may have. Since the effects of these secondary wastes have not been included, the significance of imported waste on the state's capacity is believed to be understated.

Since 1982, a steady upward trend in the amount of waste imported and exported has occurred. During this same period of time, waste transported within the state has declined. Most of the waste import/export activity occurs with the states adjacent to Illinois. Illinois is a net importer of waste from over 37 different states including Iowa, Michigan and Wisconsin. Tables 5.9 and 5.10 list the top 10 states importing hazardous wastes to Illinois in 1990 and the top 10 states to which Illinois generators sent wastes. If Illinois continues to be a net importer of hazardous wastes, Illinois' capacity issues may need to be addressed sooner than in-state generation rates would dictate.

Table 5.9. Top 10 States Importing Hazardous Waste To Illinois

State	Tons Hazardous Waste
Michigan	73,131
Indiana	47,134
Missouri	30,613
Minnesota	29,278
Wisconsin	26,762
Texas	17,019
Iowa	16,239
Colorado	11,633
Ohio	11,161
Pennsylvania	10,630

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Table 5.10. States Accepting Hazardous Wastes From Illinois 1990

State	Tons Hazardous Waste
Indiana	136,495
Missouri	50,198
Louisiana	26,964
Alabama	20,678
Wisconsin	16,713
Ohio	14,871
Texas	10,872
Michigan	8,173
Kentucky	6,002
Tennessee	2,734

Source: Summary of Annual Reports on Hazardous Waste 1990; IEPA/LPC/92-052.

Appendix 5.1: Hazardous Waste Types and Definitions

Contaminated Sand Soil and Clay (excluding spent filter media): Waste primarily composed of soil contaminated by hazardous wastes.

Halogenated Solvents: Any liquid waste that contains an organic constituent classified F001-F005 (RCRA coding), has a greater than 90 percent organic contents and greater than 0.1 percent organic halogen content. If halogen content has not been determined as organic or inorganic, the solvent is included in this category.

Nonhalogenated Solvents: Any liquid waste that contains an organic constituent classified F001-F005, and has greater than 90 percent organic content and less than 0.1 percent halogen content. The category includes solvents, for example, that contain inorganic halogen salts such as sodium chloride.

Halogenated Organic Liquids: Any liquid waste that does not contain a constituent classified F001-F005, has greater than 90 percent organic contents and greater than 0.1 percent organic halogen content.

Nonhalogenated Organic Liquids: Any liquid waste that does not contain an organic constituent classified F001-F005, an has greater than 90 percent organic content and less than 0.1 percent halogen content.

Organic Liquids, Unspecified: Any organic liquid about which nothing is known except that it's organic content may be greater than 90 percent.

Mixed Organic and Inorganic Liquids: Any liquid waste that contains an organic content of 1 percent to 90 percent, regardless of halogen or solvent content.

Inorganic Liquids with Organics: Any liquid waste that contains an organic concentration of up to 1 percent but no metals exceeding 1 part per million (ppm).

Inorganic liquids with Metals: Any liquid waste that contains an organic concentration of up to 1 percent but no metals exceeding 1 ppm.

Inorganic Liquids, Not Elsewhere Classified (nec): Acids, alkalies and any inorganic liquid with either unknown constituents; or reactive constituents such as cyanide or sulfide; or both metals in excess of 1 ppm and organics up to 1 percent.

Halogenated Organic Sludges and Solids: Any waste that contains greater than 3 percent total suspended solids, with greater than 90 percent organic content and greater than 0.1 percent halogen content.

Nonhalogenated Organic Sludges and Solids: Any waste that has greater than 3 percent total suspended solids, and greater than 90 percent organic content, but less than 0.1 percent halogen content.

Organic Sludges and Solids, Unspecified: Any waste about which nothing is known except that it is believed to contain more than 3 percent total suspended solids and have 90 percent or more organic content.

Mixed Organic and Inorganic Sludges and Solids: Any waste with more than 3 percent total suspended solids and an organic content of 1 percent to 90 percent.

Inorganic Sludges and Solids With Metals: Any waste that contains at least 3 percent total suspended solids, at least 10 ppm of RCRA regulated metals, not thought to contain organics beyond trace levels.

Inorganic Sludges and Solids nec: Any waste that contains 3 percent or more total suspended solids with other characteristics unknown, or that is reactive due to cyanide or sulfide, or contains both metals in excess of 10 ppm and organics of up to 1 percent.

Other Wastes: Any waste that is explosive, highly reactive, contaminated by dioxins, hazardous and mixed PCB's or radioactive waste, laboratory packs, or contaminated gases.

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INDUSTRIAL WASTE

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The vast majority of solid waste generated in this country is classified as nonhazardous industrial waste. These wastes are regulated under Subtitle D of the Resource Conservation and Recovery Act of 1976 (RCRA), along with several other types of waste including, municipal waste, infectious waste, agricultural waste, mining waste, and oil and gas waste. Because these wastes pose a threat to human health and the environment, as evidenced by the soil and groundwater contamination that has occurred at disposal facilities, EPA was directed to assess the adequacy of these criteria for preventing contamination as part of the 1984 Hazardous and Solid Waste Amendments.

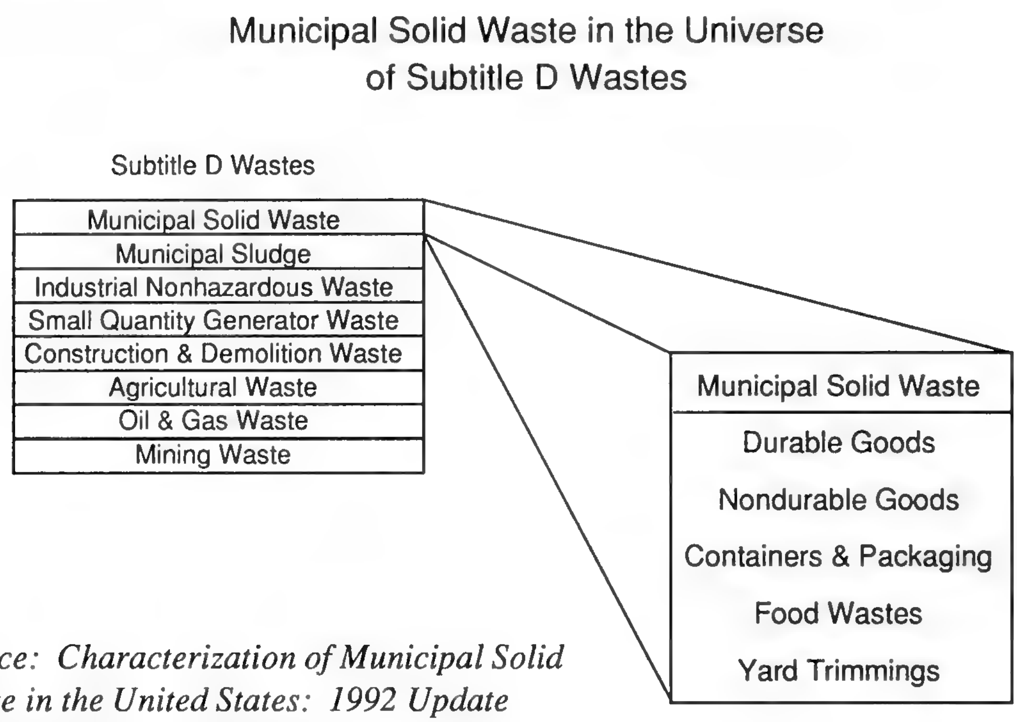
In 1979, the Illinois Pollution Control Board adopted regulations governing special waste to eliminate the unregulated disposal of certain industrial wastes and to provide a practical alternative to sole reliance on the then-existing RCRA hazardous waste guidelines. In Illinois, all solid wastes generated through industrial or pollution control processes, or those considered hazardous under RCRA, are termed "special wastes." Specifically excluded from special wastes are general household wastes, construction and demolition debris, landscape waste, uncontaminated packaging, and uncontaminated machinery components. Special wastes are regulated by the Illinois Environmental Protection Agency (IEPA) and similar data reporting is required regardless of whether the special waste is hazardous or nonhazardous. Regulatory requirements for special wastes depend on the quantity generated, whether the waste is classified as hazardous under RCRA, and the methods used to manage the waste. All special waste treatment, storage, disposal, and recovery (TSDR) facilities in Illinois must be permitted by IEPA to accept special wastes.

The IEPA *Uniform Hazardous Waste Manifest* form is used to track transfers of all special waste in Illinois. A manifest must accompany each shipment of special waste generated in quantities over 100 kg/month. Manifests include only data on special wastes shipped off-site, not those managed at the generating facility. Small quantity generators (less than 100 kg/month) can ship their own waste, but the receiving facility still requires permitting and manifesting of the wastes they receive.

All TSDR facilities are required to manifest shipments of nonhazardous special wastes. However, as of 1990, facilities are no longer required to submit the information to IEPA. Beginning in 1991, nonhazardous wastes shipped to off-site management facilities became subject to annual reporting rather than manifest reporting. The information required is similar to that provided on the manifest, e.g., identifying the TSDR facility, the generator, the quantities of waste, and management methods for the wastes received. The first Nonhazardous Special Waste Annual Report, which includes wastes reported for the 1991 calendar year, became available from IEPA in August 1993.

In 1988 IEPA began collecting data on special wastes that are managed at the facility where they were generated (on-site). Facilities report data on special wastes treated in surface impoundments or on land, and on nonhazardous wastes landfilled or stored in a wastepile longer than one year.

Nonhazardous wastes, as a group, are diverse and complex in nature and they vary in the risk posed to human health and the environment (GAO 1990). Under Illinois' regulatory system the permitting requirements for transportation and disposal are the same for all the nonhazardous industrial wastes generated in the state. To make sound decisions regarding the regulation and management of these waste streams it is important to have a system for classifying them according to the degree of hazard they pose to human health and the environment. To this end, a system for incorporating hazard considerations into the management of nonhazardous industrial waste streams was developed by the Illinois Department of Energy and Natural Resources (IDENR). This system, the Degree of Hazard system, was adopted into the regulations by the Illinois Pollution Control Board in 1990 and is used as one criteria for IEPA to consider in reviewing an industry's request to deregulate a nonhazardous special waste.



Source: Characterization of Municipal Solid Waste in the United States: 1992 Update USEPA 1992. EPA/530-R-92-019

Figure 6.1

CHARACTERISTICS AND COMPOSITION OF NONHAZARDOUS SPECIAL WASTE

Subtitle D wastes, wastes not covered under Subtitle C of the RCRA, are comprised of a wide variety of wastes, including industrial nonhazardous waste (Figure 6.1) (USEPA, 1992). The most recent estimate of the quantity and types of nonhazardous industrial waste generated annually in the United States comes from a telephone survey conducted by the USEPA (GAO, 1990). According to that survey, over 7.6 billion tons of nonhazardous industrial waste were generated in 1985 (Table 6.1). Seventeen types of industries account for 99% of all the industrial waste reported. In addition, approximately 31 million tons of construction/demolition debris wastes are generated annually (based on 1970 data) (GAO, 1990).

It was not until 1980 that standards for generators and transporters of hazardous waste were promulgated by USEPA and that permit procedures for hazardous waste programs were in place. A study was initiated by IEPA in 1979 to survey quantities, types, and fates of industrial process wastes generated in Illinois (Chillingworth et al. 1980). Approximately 20.3 million tons of industrial (special) wastes were generated in Illinois at that time (Table 6.2). The distinction had not been made between hazardous (RCRA regulated) and nonhazardous wastes at that time. Of the 20.3 million tons of industrial waste generated, 8.1 million tons were coal mining wastes (sludge and refuse) (IEPA, 1980). Of the 12.2 million tons of waste remaining, 58% (or 7.1 million tons) were managed on-site. Under current regulations, the wastes managed on-site would not have been subject to permit and manifesting regulations, as would the 4.5 million tons managed off-site. Nearly half (45%) of the wastes managed on-site were landfilled, 27% were managed through deep well injection, and 14% through long-term storage (IEPA, 1980).

Data on nonhazardous industrial wastes manifested in 1986 were analyzed by the Hazardous Waste Research and Information Center (HWRIC) (Perry, 1989). The total quantity of special waste treated, stored, or disposed in Illinois in 1986 was 4.77 million cubic yards. Of that, 79% was nonhazardous. These data were further analyzed using Standard Industrial Classification (SIC) Codes. Quantities of nonhazardous waste generated by Illinois manufacturers in 1986 and 1990 were compared for industries within each of the two digit SIC code groups (Tables 6.3 and 6.4). The 1990 data are those

Table 6.1. Seventeen Industries That Produce 99 Percent of All Industrial Waste in the United States in 1985 (in 1,000 tons)

Industry	Volume of Waste
Pulp and Paper	2,251,700
Primary Iron and Steel	1,300,541
Electric Power Generation	1,092,277
Inorganic Chemicals	919,725
Stone, Clay, Glass and Concrete	621,974
Food and Kindred Products	373,517
Textile Manufacturing	253,780
Plastics and Resins Manufacturing	180,510
Petroleum Refining	168,632
Fertilizer and Agricultural Chemicals	165,623
Primary Nonferrous Metals	67,070
Selected Chemicals and Allied Products	62,987
Organic Chemicals	58,864
Water Treatment	58,846
Rubber and Misc. Products	24,198
Transportation Equipment	12,669
Leather and Leather Products	3,234
Total	7,616,149

Source: Government Accounting Office, GAO/RCED-90-92

reported to IEPA on permit applications and manifest forms. Although many of same manufacturers are among the top nonhazardous waste producers in both years, it is difficult to make comparisons beyond that because of discrepancies between the datasets. For example, in 1986 22% of the wastes manifested did not report an associated SIC code (Perry, 1989). For the subset of the 1990 data that were analyzed by HWRIC, nearly 40% did not report an SIC code. This represents 841,258 cubic yards and 512,248 cubic yards of waste in 1986 and 1990 respectively. Other discrepancies between the dataset include wastes that were reported with no units and wastes that were not identified as hazardous or nonhazardous. Data on the distribution of wastes

Table 6.2. Illinois EPA Industrial Waste Survey Summary of Wastes Generated Annually by Waste Type for the State

Type of Waste	Waste Quantity (Tons)*	Waste Quantity (Gal)*
01 011	59,290	44,896,364
02 Solvents - Low Flash Point	60,601	10,440,761
03 Solvents - Chlorinated	22,712	2,887,926
04 Solvents - Nonchlorinated	1,122	2,328,095
05 Aqueous Liquids	31,933	25,595,060
06 Metal-containing Liquids	12,958	131,917,667
07 Cyanide & Metal Liquids	<1	40,950,758
08 Other Inorganic Liquids	116,108	482,325,895
09 Oily Sludge	122,751	12,683,523
10 Contam. Clay Filter, Sand	65,270	21,919,600
11 Dye & Paint Sludges	15,852	10,516,576
12 Fats & Waxes	482	1,781,143
13 Resin, Latex, Monomer	5,598	23,314,971
14 Chlor. Organic Sludge	144	1,008,900
15 Nonclor. Organic Sludge	42,496	95,823,756
16 Metal-containing Sludge	372,422	36,749,424
17 Metal & Cyanide Sludge	82,690	3,499,330
18 Other Inorganic Sludge	3,353,158	241,297,791
19 Metallic Dusts	167,362	11,333,100
20 Nonmetallic Inorg. Dust	1,768,651	184,098,668
21 Chlor. Organic Solids	2,350	8,088,810
22 Nonchlor. Organic Solids	56,463	43,515,967
23 Pesticides, Herbicides	748	18,458
24 PCBs	51	59,197
25 Pathogenic	<1	0
26 Explosive	1,477	928
27 Asbestos	323	2,002,282
28 Other	7,781,909	54,658,973

* Waste quantities of gallons and tons are additive.

Source: Chillingworth, et al., 1980.

Table 6.3. Estimated quantity (cubic yards) of nonhazardous special waste generated by Illinois manufacturers and TSD'ed in Illinois in 1986 (Perry 1989). SIC major groups and number of manufacturers reporting in each are given. Major groups are listed in order of decreasing quantity.

SIC Major Group	Description	Quantity	Percent of Total
34	Fabricated metal products	1,021,593	57
28	Chemical and allied products	209,676	12
35	Machinery, except electrical	159,735	9
33	Primary metal industries	122,245	7
37	Transportation equipment	121,806	7
20	Food and kindred products	42,706	2
29	Petroleum refining and related industries	33,892	2
36	Electrical and electronic machinery	21,480	1
32	Stone, clay, glass, concrete products	20,053	1
27	Printing, publishing, and allied industries	12,888	0.7
30	Rubber and misc plastics products	12,537	0.7
26	Paper and allied products	3,500	0.2
38	Measuring, analyzing, and controlling instruments	1,504	<0.1
39	Misc manufacturing industries	1,120	<0.1
31	Leather and leather products	1,082	<0.1
25	Furniture and fixtures	230	<0.1
22	Textile mill products	59	<0.1
24	Lumber and wood products, except furniture	43	<0.1
	Total	1,786,150	100

Source: Perry, 1989.

among the manufacturing SIC code groups are available from an EPA report for 1979 (Table 6.5) (IEPA, 1980). The quantities listed are for special waste, including both hazardous and nonhazardous (IEPA, 1980).

Beginning in 1991 IEPA no longer required industries and TSDR facilities to submit manifest forms documenting nonhazardous waste shipments. Annual reporting of wastes generated is now required. A summary of the data from the first of these annual reports is given in Table 6.6.

Table 6.4. Estimated Quantity (tons) of nonhazardous special waste generated by Illinois manufacturers in 1990 and shipped off-site. These data represent a subset of those retrieved from electronic files released by IEPA.

SIC Major Group	Description	Quantity	Percent
28	Chemicals and allied products	218,802	28
33	Primary metal industries	139,676	18
29	Petroleum and coal products	108,905	14
20	Food and kindred products	104,390	13
35	Industrial machinery and equipment	64,981	8
34	Fabricated metal products	42,394	5
30	Rubber and misc plastics products	35,394	4
37	Transportation equipment	25,569	3
32	Stone, clay and glass products	13,831	2
27	Printing and publishing	10,203	1
36	Electronic & other electric equipment	5,145	0.6
31	Leather and leather products	4,198	0.5
39	Misc manufacturing industries	2,912	.03
26	Paper and allied products	2,493	.03
24	Lumber and wood products	2,460	.03
25	Furniture and fixtures	652	<.01
22	Textile mill products	498	<.01
23	Apparel and other textile products	413	<.01
38	Instruments and related products	185	<.01

Source: 1993 HWRIC analysis.

Table 6.5. Quantity (tons) of special waste (hazardous and nonhazardous) generated by Illinois manufacturers in 1979.

SIC Major Group	Description	Quantity	Percent
28	Chemicals and allied products	7,488,017	58
33	Primary metal industries	1,792,371	14
29	Petroleum and coal products	350,200	3
20	Food and kindred products	656,031	5
35	Industrial machinery and equipment	575,009	4
34	Fabricated metal products	1,063,494	8
30	Rubber and misc plastics products	78,923	0.6
37	Transportation equipment	449,620	3
32	Stone, clay and glass products	28,957	0.2
27	Printing and publishing	44,645	0.3
36	Electronic & other electric equipment	85,175	0.6
31	Leather and leather products	998	<.01
39	Misc manufacturing industries	26,930	.02
26	Paper and allied products	84,225	0.6
24	Lumber and wood products	26,981	0.2
25	Furniture and fixtures	35,214	0.3
22	Textile mill products	2,545	<.01
23	Apparel and other textile products	6	<.01
38	Instruments and related products	5,968	<.01
	Total	12,795,309	**100**

Source: Chillingworth, et al., 1980.

Table 6.6. Summary of Nonhazardous Wastes Generated in Illinois in 1991

Waste Code	Waste Code Description	Quantity (cubic yards)
1	LUST Contaminated Soil, Clay, Sand	1,092,555
2	Other Contaminated Soil, Sand, Clay	302,731
3	Other Contaminated Materials	137,705
4	PCB1 (Capacitors, Transformers)	4,462
5	PCB2 (Containers)	9,357
6	Lab Packs	591
7	Leachate	60,244
8	Ashes, Incinerator or Boiler	175,534
9	Municipal Waste Water Treatment Sludges	311,168
10	Industrial Waste Water Treatment Sludges	248,155
11	Food Processing Wastes/Off-spec Products	201,265
12	Antifreeze	865
13	Waste/Used Oil	209,060
14	Other Organic Liquids	188,933
15	Other Organic Solids or Sludges	208,767
16	Liquids with Other Metals	8,736
17	Solids/Sludges with Other Metals	108,420
18	Other Inorganic Liquids	113,894
19	Other Inorganic Solids or Sludges	293,513
20	Containerized Gas	0
21	Hazardous Hospital Waste	150,922

Source: IEPA, 1993. Nonhazardous Special Waste Annual Report. 1993.

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MEDICAL WASTE

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BACKGROUND

Medical waste includes all waste produced by hospitals, clinics, physicians offices, veterinaries, nursing homes and other medical or medical research facilities. Included in this definition are the following commonly categorized waste types: general solid waste, red bag - generated in the research, diagnosis, treatment or immunization of human beings or animals, and pathological - human and animal remains, body fluids and cultures.

Definition

The definition of a waste determines the selection of the management method and therefore the cost borne by the generator. Consequently, definitional differences are very critical. The infectious component of the medical waste stream has never been uniformly defined. Due to the disparate concerns and perspectives of regulatory organizations, research, industry and medical providers, there is no universal definition applicable to suit their respective needs.

Development of a definition for infectious wastes is difficult. There are no tests available to objectively identify infectious wastes, unlike chemical or radiological (cancer treatment) wastes. Therefore, state and federal agencies rely on identification of infectious wastes based upon waste category and composition. The Illinois statutory definition of potentially infectious medical waste is included at the end of this chapter.

There are two sets of federal guidelines for generators of medical waste. These dissimilar guidelines were developed by the United States Environmental Protection Agency (USEPA) and the Center for Disease Control (CDC), respectively. Each set was written with a different objective in mind. For example, the CDC guidelines were developed for health care worker safety. USEPA's definition was meant to apply to waste management. The result is that neither guideline is totally appropriate for both waste management and health care worker safety.

USEPA defines infectious waste as waste that is capable of producing an infectious disease. The following factors must be considered in conjunction with this particular definition: presence of a pathogen of sufficient virulence, dose, portal of entry, and resistance of the host.

Therefore, for a waste to be infectious, it must contain pathogens with sufficient virulence and quantity so that exposure to the waste by a susceptible host could result in an infectious disease. While this particular analysis appears to be straightforward, its application may be difficult. While a waste generated by a single individual may be easy to categorize under this test, wastes produced by multiple individuals in multiple locations within a generator site may not be.

The CDC guidelines adopted in 1987, are commonly referred to as universal precaution procedures. These guidelines provide that blood and body fluids from all patients be considered potentially infected with HIV and/or other blood-borne pathogens and that health care workers adhere rigorously to infection control precautions. These very broad guidelines lead to some interpretative problems. Consequently, in 1988 CDC issued clarified guidelines. The universal precaution procedures are now limited to blood and other body fluids containing visible blood, semen and vaginal secretions, and to other specified fluids.

Notwithstanding the definitional differences, the EPA and CDC guidelines both designate pathological waste, blood and blood products, contaminated sharps and microbiological wastes as infectious.

Regulatory History

Historically, infectious wastes received little federal regulatory attention. However, in response to the infamous east coast beach wash-ups of 1988, Congress passed the Medical Waste Tracking Act of 1988. This law merely authorizes USEPA to conduct a national medical waste tracking and research study. It will focus on issues relative to medical waste management and generation that may form the basis of national policy and regulation.

The USEPA, under the Resource Conservation and Recovery Act (RCRA), and the Clean Air Act (CAA) and the Occupational Safety and Health Administration under the Occupational Safety and

Health Act (OSHA) have the authority to regulate different aspects of infectious waste management. OSHA's authority extends to areas concerning worker safety. EPA on the other hand, may regulate transportation, disposal, labeling, packaging, disposal and treatment. Medical radiological wastes are currently regulated by the Nuclear Regulatory Commission standards.

RCRA's statutory definition of hazardous waste includes infectious as a defining characteristic. However, when the waste management regulations were developed in the late 1970's, USEPA elected to classify infectious wastes as neither hazardous nor solid waste. The final USEPA rules, issued in 1980, stated that infectious waste regulations would be proposed at a later date. USEPA stated that not enough information on the subject was available at the time to support the promulgation of federal regulations. To this date, no federal solid waste management regulations have been proposed.

Over the last five years there has been an increase in public concern regarding infectious waste management practices. Due to the lack of federal regulations, many states and local governments have enacted laws and ordinances to control the management and transportation of infectious wastes; 44 states had such laws. This reflects public support for regulation of medical waste. There currently exists a large variation in the laws governing infectious waste across the country. As the patchwork of regulations has developed, so has concern that stricter regulations in one state or locality may encourage the shipment of wastes to other places that do not have infectious waste laws. The understanding and interpretation of a myriad of environmental laws make compliance difficult for both generators and management facilities.

Illinois Regulations

Like many other states around the country, Illinois has undertaken the regulation of medical wastes. The Illinois EPA (IEPA) has effectively administered regulations pertaining to disposal, transport and treatment of medical wastes for several years.

Beginning in 1985, the Illinois Environmental Protection Act (Ill. Rev. Stat. 1991, ch. 111½, par. 1001 et seq.), designated medical wastes as "special" wastes. Additionally, solid waste regulations at 35 Ill. Adm. Subtitle G, Subpart F, Sections 700.601-700.605 were promulgated to further regulate hospital medical waste management. These regulations, require that infectious hospital waste be rendered innocuous by sterilization or incineration prior to disposal and that it be manifested for transportation to a treatment or disposal facility.

In response to public pressure, the 1991 legislative session saw the adoption of amendments to the Illinois Environmental Protection Act. To implement the changes, regulations at Ill. Adm. Code Title 35: Subtitle M, Chapter I, Part 1420-1422 were written. These regulations put forth a state definition of infectious waste (Potentially Infectious Medical Waste, PIMW). PIMW is defined as a "special" waste generated in connection with the diagnosis, treatment, or immunization of human beings or animals; research pertaining to provision of medical services; or production and testing of biological items. (This definition is consistent with the USEPA guidelines.)

The Illinois PIMW regulations affect transportation, storage, treatment and disposal of PIMW such that:

- Effective January 1, 1992, PIMW was banned from landfill disposal except for sharps where (1) the infectious potential has been eliminated by treatment, and (2) the sharps are packaged in accordance with the Act and effective regulations.
- Starting January 1, 1992, PIMW must be transported by a permitted PIMW hauler with a completed manifest.
- The imposition of a 1.5 cent per pound transportation fee is also effective July 1, 1992.
- PIMW may only be transported to a storage, treatment or transfer facility that has been permitted by the IEPA.

On June 17, 1993, The Illinois Pollution Control Board adopted final regulations for the treatment, storage and transfer of PIMW and Standards for the transportation, packaging and labeling of PIMW. The adopted rules amend 35 Ill. Adm. Code 1420 and add new Parts 1421 and 1422 to the Board's regulations.

Many states, including Illinois have regulations that set emission limits for medical waste incinerators. Illinois regulations prescribe particulate and carbon monoxide emission limitations for incineration (Ill. Adm. Code Title 35: Subtitle B, Chapter I, Subpart D, Sections 216.141 and 212.181-212.185).

Under the Clean Air Act Amendments of 1990, there are requirements for EPA to regulate medical waste incinerators. The development of Illinois regulations to implement the CAA allows the state an opportunity to adopt specific emission limitations applicable to a broader range of pollutants and incinerator units. Reduction of toxic emissions from incinerators, beyond those required by the USEPA, is therefore possible. USEPA has yet to develop testing guidelines regulating biological emissions from medical waste incinerators. A proposal of medical incineration regulations under the Clean Air Act is expected in March 1994 and promulgation in August 1995. IEPA will have one year to promulgate regulations in accord with federal guidelines for existing medical waste incinerators. Medical incinerators will have 3 years to comply.

History of Medical Waste Generation and Management

The actual amount and composition of medical waste generated presently and in the past are not known. Estimates exist, but these are not based on hard data. General hospital solid waste has always been considered part of the municipal solid waste stream. For this reason, no specialized tracking or reporting systems were implemented nationally to collect accurate data. Even though Illinois has regulated hospital hazardous waste as special waste since 1985, data is not available specific to waste volumes and composition. Without reliable data on generators, treatment facilities, waste volumes and composition, it is difficult to write new regulations and to estimate their impact.

MEDICAL WASTE GENERATION

Categorization of Waste Generators

Medical wastes are generated by a wide variety of both private and public organizations. According to the Illinois Department of Public Health in 1990, there are 69 ambulatory surgical health centers, 242 rural health clinics, 1245 nursing homes, 4258 labs, and 99 renal disease centers in Illinois. The 1990 American Hospital Association, Guide to the Health Care Field, lists Illinois with 249 licensed hospitals. The Illinois Department of Professional Regulation has 8,080 dentists registered to practice in this state. Combined there are at least 14,200 potential generators of medical waste in Illinois. This figure does not account for the blood banks and veterinarians.

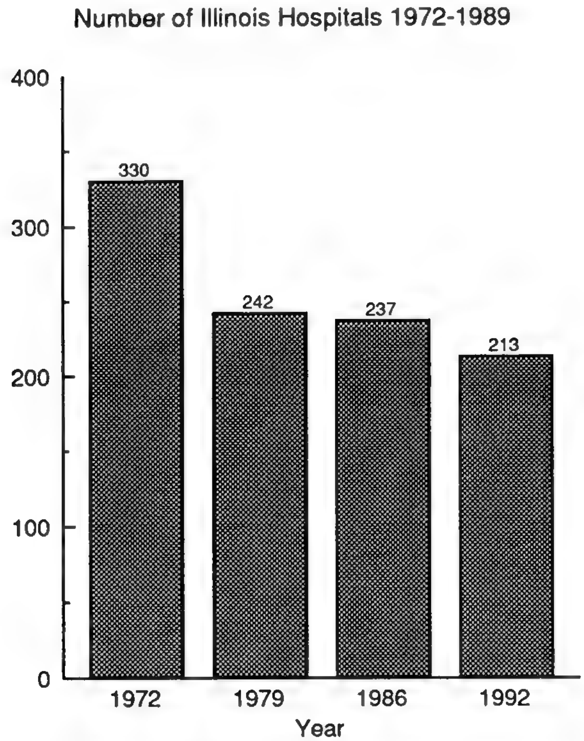
It is generally accepted that hospitals produce the largest volume of medical waste per patient (as opposed to physician's offices, blood banks, etc.). It is therefore important to note trends that may affect their rate of waste production. For example, more surgeries produce more waste per patient.

Information from the U.S. and Illinois Statistical Abstracts show that Illinois is consistent with national trends in health care services. From 1972 to 1989 the number of hospitals declined by 36 percent; the total number of beds decreased by 46 percent (Figures 7.1 and 7.2). Although national occupancy rates for hospitals declined from 84 to 68 (average daily census to every 100 beds), the number of surgical operations increased by almost 21 percent (Figures 7.3 and 7.4). Illinois on the other hand seems to have maintained the status quo with respect to number of surgical procedures. No factors are identified which would alter this trend in the near future.

Characterization of the Waste Stream

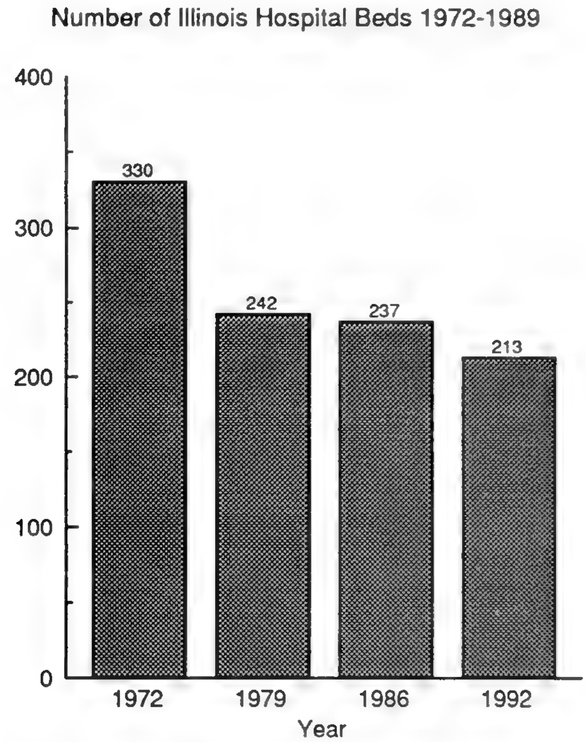
Little reliable information exists on the composition of medical wastes. It is appropriate to say that medical waste is heterogeneous in nature and is generally composed of refuse (office paper, food waste, and non-infectious patient waste), infectious waste (pathological wastes, human blood and blood products, contaminated sharps, anatomical wastes and isolation wastes), hazardous wastes (waste pharmaceuticals, cytotoxic agents used in chemotherapy, mercury or other heavy metals) and radioactive wastes. However, even the above composition varies depending on the type of services offered by the generator facility and the daily activities and procedures performed. It is therefore difficult for both generators and the regulatory agencies to predict the volume and characterization of waste produced on a regular basis.

In order to understand the waste generation and management issues of medical waste it is important to analyze the composition of the waste stream. The following characterization of hospital waste was taken from USEPA's *Hospital Waste Combustion Study: Data Gathering Phase*. (This research was originally presented by *A.C. Jenkins*, Evaluation Test on a Hospital Refuse Incinerator at Saint Agnes Medical Center, Fresno, CA. (California Air Resource Board, Stationary Source Division, January 1987)). The Jenkins data illustrates that on a per weight basis, hospital waste is composed of approximately 65%



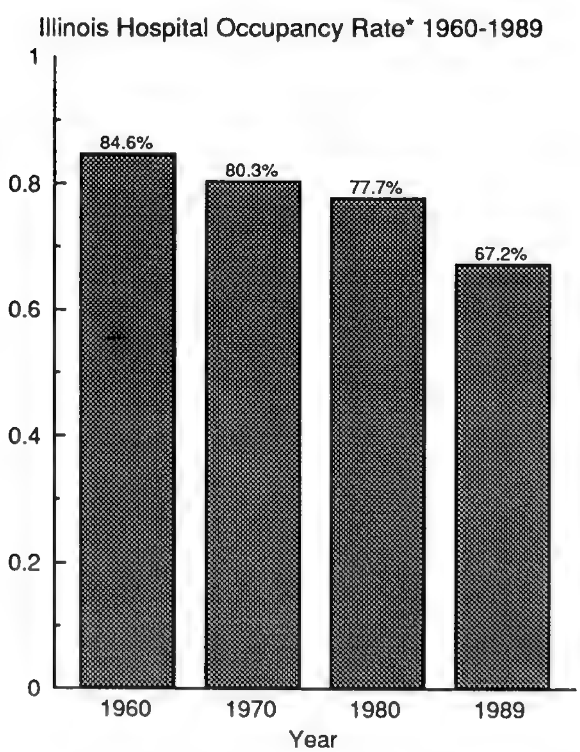
Source: U.S. Statistical Abstract, Illinois Statistical Abstract

Figure 7.1



Source: U.S. Statistical Abstract, Illinois Statistical Abstract

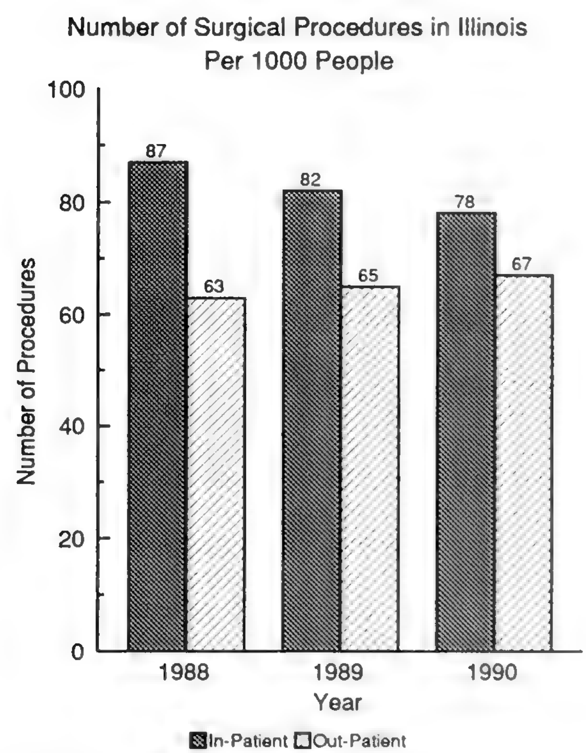
Figure 7.2



*Ratio of average daily census to every 100 beds

Source: U.S. Statistical Abstract, Illinois Statistical Abstract

Figure 7.3



Source: U.S. Statistical Abstract, Illinois Statistical Abstract

Figure 7.4

paper, 30% plastic, 5% other and 10% moisture (percentages do not add to 100 since they are approximations).

This study shows that a large portion of the waste stream is combustible. Paper products and plastics constitute 95 percent by weight of the waste stream. These materials have high Btu values and may produce toxic emissions when burned.

The volume of infectious waste produced by a facility can vary widely, depending on infectious material guidelines or practices employed. For example, using CDC guidelines for infectious wastes approximately 3 to 5 percent of a hospital's total waste stream would be classified as infectious. Using USEPA guidelines, 10 percent would be classified as infectious. Using the Universal Isolation Precaution Guidelines of August 1987, the volume could be at least 80 percent of the total. Additionally, if infectious waste is mixed with a non-infectious waste, the entire quantity is considered infectious. For purposes of cost containment and infectious control management, most hospitals have some type of waste segregation practice in place.

A 1984 study of Illinois hospitals revealed that 85 percent of a hospital's waste stream can be categorized as general refuse. The remaining 15 percent is contaminated with infectious agents. This is close to the 10 percent estimated using the USEPA guidelines.

Volume of Medical Waste Generated Over Time

Several limited studies attempted to determine the current volume of medical waste generated nationally. These studies have relied upon small samples, best estimates and statistical manipulation to produce results.

The Office of Technology Assessment's *Issues in Medical Waste Management, Background Paper*, includes national estimates of medical waste generation. According to this report, the USEPA estimates that approximately 3.2 million tons of medical waste from hospitals are generated each year, which is about 2 percent of the total municipal solid waste stream. Other estimates range from 2.1 to 4.8 million tons. USEPA believes that most generators of medical waste designate between 10 and 15 percent infectious. This means that using the 15 percent figure, 210,000 to 720,000 tons per year are infectious waste. *These figures do not include medical wastes from sources other than hospitals.*

In 1987, USEPA reported that hospitals generated approximately 13 pounds per bed per day of medical waste. Other studies dispute this number and propose a range of between 8 to 45 pounds per bed per day. A Florida study of seventeen hospitals show an average of 23 pounds per bed per day generated. Comparing the results of an 1980 survey in North Carolina, showing an average generation figure of 10 pounds per bed per day, to either the USEPA figure of 13 pounds or the Florida study of 23 pounds, a significant increase appears to have occurred over the past ten years.

Hospitals indicate that the amount of disposable materials, including plastics, has increased dramatically in recent years. This would support the studies that show there has been a per bed increase in waste generation over the past decade.

MEDICAL WASTE MANAGEMENT

There are several treatment methods used for medical waste including the following: thermal inactivation, irradiation, incineration, microwave treatment, steam sterilization, grinding and shredding, gas sterilization, compaction, and chemical disinfection with grinding. Of these, incineration and autoclaving (stream sterilization), are predominantly used by generators prior to off-site disposal.

There are few commercial medical waste incinerators in the country. Illinois has one commercial incinerator and no commercial autoclaving facilities in operation today. Therefore, in this state a majority of incineration and all sterilization occur on-site where the waste is generated. Users of commercial treatment facilities include small generators, e.g., dentists, doctor's offices, etc.

Unlike municipal refuse incinerators that only burn wastes received from off-site, non commercial medical waste incinerators only burn waste that is generated on-site. Consequently, they are small units usually located in well-populated areas. On-site medical waste incinerators are relatively inexpensive to operate, require a minimum amount of operator training and are generally not subject to extensive regulatory review, testing and oversight. Incineration reduces the volume of material going to landfill, thereby reducing the cost of disposal to the generator.

The mixing of waste types is a problem that effects proper disposal and treatment. If on-site incineration occurs, it is likely that some of the facility's waste is mixed, i.e., general refuse mixed with pathological waste. If the waste is shipped off-site it is likely that proper segregation occurs due to the costs involved with treatment and disposal of different waste types.

Federal laws do not require hospitals to report the type and quantity of medical waste incinerated or sterilized on-site. For this reason, most estimates are based upon small studies of on-site hospital waste management practices. From a 1983 American Hospital Association survey, 67 percent of U.S. hospitals use on-site incinerators; 16 percent use only autoclave systems and then landfill; and approximately 15 percent use off-site treatment exclusively. While these numbers probably still hold true in 1993, there appears to be a trend toward off-site treatment due to the changing regulatory climate and pressure from the public to remove treatment from the hospital premises.
Beginning in 1993, Illinois PIMW facilities are required to report volumes of waste managed on-site.

Autoclaving

Autoclaving, or steam sterilization, is a process to sterilize medical waste prior to disposal in an off-site landfill. Since the mid-1970's it has been a preferred treatment method for micro biological laboratory cultures. Other wastes (e.g., pathological tissue, chemotherapy waste, and sharps) may not be adequately treated by some sterilization operations, however, and therefore is incinerated. No data exists on national autoclaving quantities.

The autoclaving process includes the containment of bags of waste in a pressurized chamber for roughly 15 to 30 minutes. Temperatures are usually maintained at 250°F to 270°F. Various factors (moisture content, volume and density of material) have an important influence on the effectiveness of the autoclaving sterilization process. Autoclaving parameters of temperature and residence time (how long the waste stays in the autoclave at the optimum temperature) determine the extent of the sterilization.

Many hospitals have switched from autoclaving to other forms of waste management due to various factors. Problematic operating conditions can easily lead to incomplete sterilization of the waste. Landfills frequently do not accept autoclaved waste as it is not possible to verify sterilization.

Incineration

The typical medical incinerator is located in an urban area close to buildings. This is true for all types of generators, e.g., hospitals, clinics, crematoriums and veterinary clinics. Most incinerators have short stacks that may allow emissions to enter the building air. Many on-site incinerators are old and lack control equipment. This results in relatively high emission rates and production of quantities of contaminants of high risk. It is likely that waste streams may be mixed, and the potential for complete destruction of pathogens is questionable. (Mixed waste streams consist of wastes with heterogeneous composition, e.g., chemicals, moisture, organic material and plastic content.) Hospital waste is seldom pre-processed; it is burned in bulk on a mass feed basis. Incinerator operators have minimum operator training. Most medical incinerators are operated on an intermittent basis. Frequent startups and shutdowns may lead to incomplete combustion and the formation of dioxins and furans. Individually and collectively, hospital incinerators burn much less waste than do municipal incinerators. Hospital incinerators usually have a capacity to burn from 50 to 1500 pounds per hour. Most units fall toward the low end of this range.

The objective of incineration is to reduce the size and mass of the waste and to render it innocuous (no longer infectious). Specific problems related to medical waste composition include variable ash content, low heating (Btu) value and corrosive materials. Factors that can influence combustion performance are fuel feeding patterns, air supply and distribution, heat transfer, and ash disposal.

Med X in Clinton, Illinois, is this state's only commercial medical waste incinerator. It has two fixed hearth units, each rated at 1500 pounds per hour. Trade Waste Incineration, a hazardous waste incinerator in Sauget, is permitted to accept medical waste, but does so on a limited basis.

Classification of Incinerators

For many years incinerator purchasers have relied upon a waste classification system developed by the Incinerator Institute of America (Table 7.1). This system primarily is used for small, non specialized incinerators usually purchased by hospitals, stores and small businesses for on-site waste disposal. The incinerator manufacturers design, test and market different models according to this classification

Table 7.1. Incinerator Institute of America Solid Waste Classifications

Type 0	Trash, mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes from commercial and industrial activities. Contain up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags, and plastic or rubber scraps.
Type 1	Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage, and combustible floor sweepings from domestic, commercial and industrial activities. The mixture contains up to 20 percent by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber wastes. This waste contains 25 percent moisture, 10 percent incombustible solids and has heating value of 6,500 Btu/LB as fired.
Type 2	Refuse, consisting of an approximately even mixture of rubbish and garbage by weight.
Type 3	Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets and like installations.
Type 4	Human and animal remains, consisting of carcasses, organs, and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85 percent moisture, 5 percent incombustible solids, and having a heating value of 1,000 Btu per pound as fired.
Type 5	By-product waste, gaseous, liquid or semi liquid, such as tar, paints, solvents, sludge, fumes, etc., from industrial operations. Btu values must be determined by the individual materials to be destroyed.
Type 6	Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations. Btu values must be determined by the individual materials to be destroyed.

system.

This classification scheme does not address more recent concerns such as plastic content, possible hazardous components and waste composition variability. Most medical waste incinerators currently operating in Illinois were originally rated according to this scheme. The Illinois Environmental Protection Agency still uses this system to designate the type of waste an incinerator is permitted to burn. Since medical waste stream composition tends to be highly variable, the use of such a classification system in the permitting process may pose problems. For example, the ratings and the stack tests performed to obtain a operating permit are based upon the above specified compositions. On the other hand, the day to day waste composition produced by a particular medical provider may be extremely different. The resulting incinerator operation and emissions will reflect the difference between the optimal and the actual waste compositions. This is particularly important since most incinerators do not have control equipment and are located in populated areas.

Air Pollution and Toxic Emissions

The majority of pollutants emitted from incinerators are criteria pollutants, which include particulate matter, acid gases (HCl, HF and SO2), nitrogen oxides (NOx) and carbon monoxide (CO). They also emit small amounts of trace organics and trace metals, which are classified as toxic pollutants.

Emissions from medical incinerators tend to consist of more dioxins and furans per gram of waste burned than from municipal incinerators. The reasons for this include frequent startups and shutdowns, less stringent emission control, poorer combustion control (waste mixing and oxygen controls) and differences in the waste feed composition as compared with municipal solid waste.

Destruction of precursors in the furnace and control of temperatures in the stack are important factors in preventing formation of dioxins and furans. Disagreement exists over whether pyrolysis of PVC in hospital incinerators can produce chlorobenzene (a potential dioxin precursor). Upset conditions in testing of incinerators burning PVC and polyethylene generate large quantities of products of incomplete combustion, including dioxin. It has been found during tests that dioxins are formed in cool sections of the incinerator. If startups and shutdowns of the medical waste incinerator occur without auxiliary fuel, poor combustion may allow dioxin precursors to escape up the stack. Additionally, start ups and shut downs may lead to the volatilization of certain waste components, including pathogens. To reduce formation of precursors, increased mixing time and temperature are required. Sophisticated combustion controls and monitors that regulate the level of oxygen in the furnace can improve destruction of precursors. Table 7.2 presents the results of a comparative study completed by USEPA on municipal and hospital incineration facilities.

Table 7.2. Dioxin and Furan Emission Concentrations (in ng/Nm³)

Facilities	Total Dioxins	Total Furans
*Hospitals:**		
A	160-260	386-700
B	290-450	700-785
C	117-197	52-84
Municipalities:		
Hampton, NY	243-10,700	400-37,500
North Andover, Mass	225	323
Marion Co., Oregon	1.13	
Prince Edward Is, Canada	60-125	100-160
Tulsa, Oklahoma	18.9	15.5
Wurzburg	22.1	27.9
Akron, Ohio	258	679

* Exact locations of hospitals were not reported in the study.

Source: CC Lee, G. Huffman, and T. Shearer, "A Review of Biomedical Waste Disposal" (US EPA, Feb. 19, 1988)

As of 1987 most states did not require control of opacity and particulate emissions from hospital incinerators. Today this is the maximum requirement in most states; standards and controls are not required for the other constituents. Reported ranges of concentrations of various constituents in hospital emissions are listed in Table 7.3.

Concentrations of hydrogen chloride appear to be consistently higher, on average, compared to municipal incinerators. It is suggested that this is due to higher levels of PVC plastics in medical wastes (as high as 30% by weight in medical waste vs. 5 to 10% by weight in the municipal waste stream). HCl emissions may be controlled by operational considerations (waste stream composition and

Table 7.3. Concentrations of Constituents in Emissions from Hospital Incinerators Without Particulate Control Devices

Constituent	Range of Emissions*
Arsenic	1-5.99 gr/dscf
Cadmium	24.7-140 gr/dscf
Chromium	2.15-30.9 gr/dscf
Lead	532-1190 gr/dscf
Nickel	2.22-8.0 gr/dscf
TCDD	3.3-38.5 ng/Nm³
Total Dioxins	51.8-450 ng/Nm³
TCDF	18.9-79.8 ng/Nm³
Total Furans	117.3-785 ng/Nm³
HCl	41-2095 ppmv
SO^2	19-50 ppmv
NO_x	

*gr/dscf = grains per dry standard cubic foot; ng/Nm³ = nanograms per standard cubic meter; ppmv = parts per million volume

Source: US EPA, "Hospital Waste Combustion Study, Data Gathering Phase" final draft, October 1987

volume) or through the installation of control equipment, such as acid gas scrubbers.

Incinerator Ash

Very little information has been collected on the constituents found in incinerator ash. Heavy metals would be expected to be found in the ash as it is in incinerator stack emissions. The data from one study shows that concentrations of both dioxins and furans are considerably higher in hospital incinerator ash than in municipal incinerator ash (Table 7.4). Hospital incinerator ash concentrations for dioxins exceed the CDC and EPA standards by about two orders of magnitude. While a great deal of research on this topic is not available, most studies indicate that medical waste incinerator ash may be a source of environmental concern. The results of a 1987 study illustrate the basis of this concern. Medical waste incinerator ash is accepted at Illinois landfills that are permitted to take special waste.

Table 7.4. Fly Ash from Municipal and Hospital Incinerators (ng/Nm^3, equivalent to parts per billion)

Incinerator Type		
Constituent	Municipal	Hospital
2,3,7,8-TCDD	0.03-0.34	1.4-3.4
Tetra CDD	0.6-7.5	94-404
Penta CDD	1.2-13.2	208-487
Hexa CDD	1.4-15.8	271-411
Hepta CDD	1.8-25.6	189-307
Octa CDD	1.9-23.1	123-245
Total Dioxins	**6.9-80.3**	**1155-1737**
Tetra CDF	9.0-32.1	199-376
Penta CDF	10.2-38.3	285-647
Hexa CDF	8.0-31.7	253-724
Hepta CDF	3.4-15.9	125-286
Octa CDF	0.7-4.6	25-134
Total Furans	**31.3-119.5**	**895-2140**

Source: H. Hagenmaier, M. Kraft, H. Brunner, and R. Haag, "Catalytic Effects of Fly Ash from Waste Incineration Facilities on the Formation and Decomposition of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans," Environment, Science and Technology 21 (11)" 1080-1084, 1987.

Concentrations of Dioxins and Furans in Bacterial Emissions

The subject of bacterial and viral emissions from the handling and management of infectious waste is one of the least studied and understood. Bacterial emissions from incineration are not regulated on either the state or federal level. Recent public concern regarding the spread of disease, may shift the focus of regulatory agencies and researchers to the study of infectious emissions management.

In 1988 the University of Illinois at Chicago published the results of a study of bacterial emissions from the burning of hospital waste . The purpose of the study was to examine the emissions from a hospital incinerator to determine whether or not human pathogenic bacteria were being released into the air. Not only did the incineration of the hospital's waste produce a stack gas very high in particulate matter (20 times the emission standard) and hydrochloric acid which made sampling for bacteria impossible, but also, concentrations of combustion gases (02, CO2, CO, N2 and H2O) were outside the ranges of these variables reported at other hospital incinerators. As an alternative to the hospital's waste, the testing was completed using substitute waste consisting of paper products and water, and spiked with Bacillus subtilis, a spore forming bacteria. The substitute waste solved the testing problems and allowed the evaluation to proceed.

No Bacillus subtilis was found in the stack gas. The number and species of bacteria collected from the stack gas were different from other bacteria collected in simultaneous outdoor air samples. It was hypothesized that the source of the bacteria was the excess combustion air added primarily in the secondary combustion chamber. The results of sampling and analysis of incinerator room air, the source of the combustion air, showed bacteria number and species similar to that found in the stack gas. The evidence suggests that the source was the excess combustion air entering the secondary combustion chamber. With regard to the indoor air, the results of the study found that waste repackaging could be the source of this contamination. Other contributing operations could be the collection and transport of the waste at the hospital. The study recommended that waste handling practices at hospitals should be evaluated to determine whether or not their implementation could create new bacterial emission sources. Additionally, it was concluded that further research be conducted to incorporate simultaneous sampling of indoor air, combustion air, stack gas, and outdoor air.

COSTS OF MEDICAL WASTE TREATMENT AND DISPOSAL

As with other information relative to medical waste, there is little historical or current information available on the costs associated with disposal and treatment. Furthermore, there is no mechanism in place to routinely gather this information. National cost estimates for 1988 were $0.01 to $0.25 per pound for general non- infectious refuse (usually landfilled), $0.10 to $0.25 per pound for incineration on-site (includes infectious wastes), and $0.30 to $1.00 per pound for commercial, off-site incineration. It is not possible to determine if these numbers are representative of costs borne by Illinois medical waste generators.

If the above cost figures are applicable to this state, the cost of on-site incineration is lower than is the cost of commercial off-site incineration. This could account for the increase in the number of on-site incinerators built over the past several years.

ILLINOIS FACILITIES

A review of IEPA data on permitted medical waste incineration facilities for the years 1983 through 1989 shows an increase in the number of incinerators located in Illinois. See Figure 7.5.

Incinerators are located at a wide variety of both public and private business and service entities. Table 7.5 lists the Standard Classification Codes (SIC) describing facilities where incinerators are located.

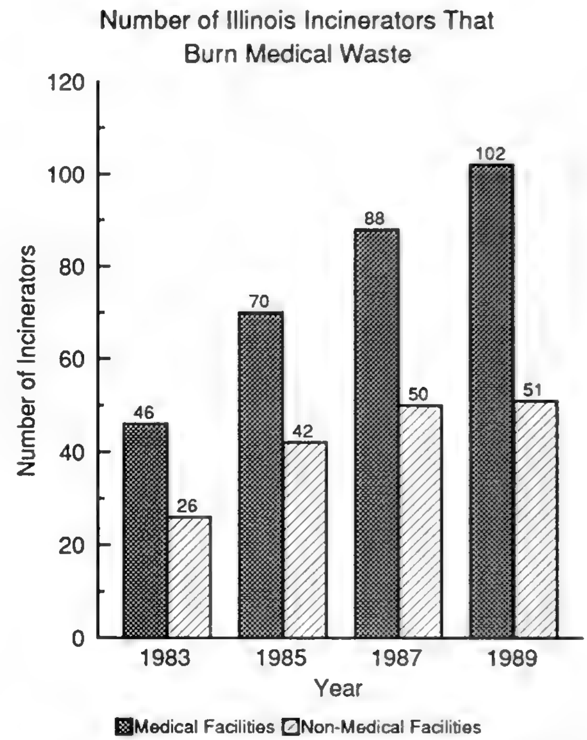
Table 7.5. Incineration SIC's: Type 4, 7 and Hospital Hazardous Waste

Poultry production	251	Physician's offices	8011
Vets/animal hospitals	742	Hospitals	8062
Animal specialty services	752	Blood banks	8091
Sewerage systems	4952	Universities	8221
Refuse systems	4953	Animal shelters	9199
Crematories	7261	Military	9711
Research laboratories	7391		

Source: DENR review of IEPA data.

IEPA data show that the largest number of incinerators that burn human medical waste are located at medical facilities. SIC numbers 8011-Physician's Office, 8062-Hospital, 8091-Blood Bank, and 8221-Universities (primarily university hospitals) are included in the medical category. In 1983, 64 percent of the incinerators were located at medical facilities. In 1989, the number had increased only by 3 percent to 67 percent of the facilities. However, the number of medical incinerators increased from 46 units in 1983 to 102 units in 1989 (Figure 7.5).

While the ratio of medical facility incinerators to non medical facility incinerators has remained constant,



Medical facilities include physician's offices, hospitals, blood banks, university hospitals. Other types of facilities include crematories, animal shelters and research laboratories, among others.

Source: DENR Review of IEPA Data 1993

Figure 7.5

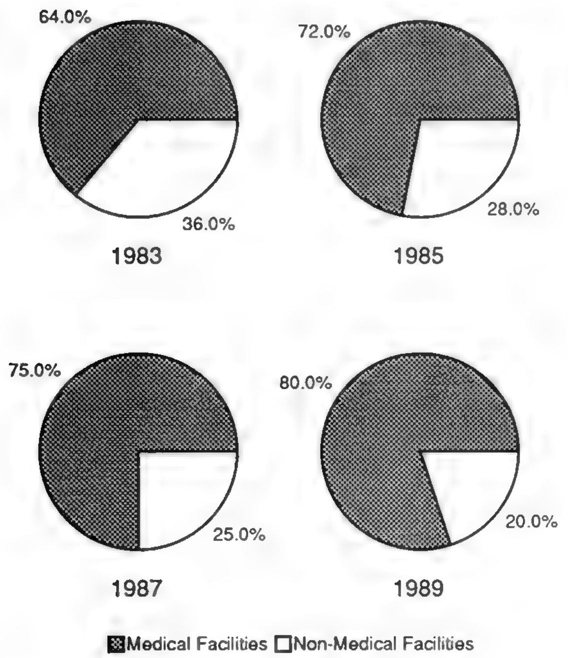
the percent of particulate emissions generated has not. As shown in Figure 7.6, these medical incinerators produce a significant proportion of the total suspended particulate emissions generated from the burning of medical wastes. This number continues to grow.

TRENDS IN THE GENERATION OF MEDICAL WASTE

The available data on the medical waste stream suggests that the disposable component is going to continue to increase. More paper and plastics are being produced. Medical supply manufacturers, unless forced by government regulations, are not motivated to move toward recyclable products and containers. Reformulation of plastics to reduce HCl emissions and the production of precursors may provide some reduction in toxic emissions from the incineration of wastes.

The amount of medical waste generated is expected to increase. As the population grows and ages, so

Source of Total Suspended Particulates from
Medical Waste Incinerator Facilities



Source: DENR Review of IEPA Data, 1993
Figure 7.6

will the volume of medical waste produced. Better understanding and application of infectious definitions may also serve to increase the amount of waste requiring infectious management practices.
Trends in Medical Waste Management.

The current popularity of on-site management may change if regulations are enacted that force compliance with more complex and expensive pathogenic standards, emission controls and ash disposal methods. Generators may be compelled by the cost of control equipment, operator training, stack testing and insurance to seek off-site waste management. It is likely that this will result in the building of more commercial facilities. Existing commercial facilities may find the market strong enough to seek permits to accept medical wastes.

Appendix 7.1: Illinois' Potentially Infectious Medical Waste Definition

"Potentially infectious medical waste" means the following types of waste generated in connection with the diagnosis, treatment (i.e., provision of medical services), or immunization of human beings or animals; research pertaining to the provision of medical services; or the production of testing of biologicals:

Cultures and stocks. This waste shall include but not be limited to cultures and stocks of agents infectious to humans, and associated biologicals; cultures from medical or pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; wastes from the production of biologicals; discarded live or attenuated vaccines; or culture dishes and devices used to transfer, inoculate, or mix cultures.

Human pathological wastes. This waste shall include tissue, organs, and body parts (except teeth and the contiguous structures of bone and gun); body fluids that are removed during surgery, autopsy, or other medical procedures; or specimens of body fluids and their containers.

Human blood and blood products. This waste shall include discarded waste human blood, blood components (e.g., serum and plasma), or saturated material containing free flowing blood or blood components.

Used sharps. This waste shall include but not be limited to discarded sharps used in animal or human patient care, medical research, or clinical or pharmaceutical laboratories; hypodermic, intravenous, or other medical needles; hypodermic or intravenous syringes; Pasteur pipettes; scalpel blades; or blood vials. This waste shall also include but not be limited to other types of broken or unbroken glass (including slides and cover slips) in contact with infectious agents.

Animal waste. Animal waste means discarded materials, including carcasses, body parts, body fluids, blood, or bedding originating from animals inoculated during research, production of biologicals, or pharmaceutical testing with agents infectious to humans.

Isolation waste. This waste shall include discarded waste materials contaminated with blood, excretions, exudates, and secretions from humans that are isolated to protect other from highly communicable diseases. "Highly communicable diseases" means those diseases identified by the Board in rules adopted under subsection (e) of Section 56.2 of this Act.

Unused sharps. This waste shall include but not be limited to the following unused, discarded sharps: hypodermic, intravenous, or other needles; hypodermic or intravenous syringes; or scalpel blades.

Potentially infectious medical waste does not include:

waste generated as general household waste;

waste (except for sharps) for which the infectious potential has been eliminated by treatment; or

sharps that meet both of the following conditions:
the infectious potential has been eliminated from the sharps by treatment; and
the sharps are rendered unrecognizable by treatment.

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LOW LEVEL RADIOACTIVE WASTE

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Low Level Waste (LLW) describes various radioactive materials that are no longer usable and materials that have been radioactively contaminated. LLW is defined as "radioactive waste not classified as transuranic waste, high level radioactive waste, spent nuclear fuel, or byproduct material (mill tailings)," as defined in Section 11e.(2) of the Atomic Energy Act of 1954 (42 U.S.C. 2014) LLW can be gaseous, solid or liquid. Any time radioactive matter is used as part of an activity, some LLW is generated.

Radioactive materials, including LLWs, are regulated by state and federal agencies. This discussion does not include LLW owned or generated by the U.S. Department of Energy, the U.S. Navy naval vessel decommissioning, or LLW generated as a result of atomic weapons programs.

There are several agencies involved in the regulation of radioactive materials and disposal of LLW. The primary federal regulators are the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency (USEPA). In addition, the U.S. Department of Transportation provides rules for the transport of radioactive materials. State governments, including Illinois, also have regulatory responsibilities. In Illinois that responsibility lies with the Department of Nuclear Safety (IDNS).

U.S. Nuclear Regulatory Commission
Under the Atomic Energy Act of 1954, the NRC is responsible for licensing and regulating certain nuclear facilities including commercially operated nuclear power plants and the production, use, ownership, distribution, importation and exportation of special nuclear materials, source material and by-product material. Amendments to the Atomic Energy Act allow for the NRC to delegate authority to states for regulatory control. Illinois was granted Agreement State status in June of 1987. This agreement has allowed Illinois to develop its own regulations to protect the public health and safety. Such state regulations must be as stringent as the equivalent NRC regulations.

U.S. Environmental Protection Agency
The USEPA is authorized to regulate radioactive materials in specific areas concerning environmental radiation standards, radiation exposure limits, air and water pollution control, regulation of ocean dumping, maintenance of drinking water purity and control of hazardous substances.

Illinois Department of Nuclear Safety
In 1983, in response to the federal Low-Level Radioactive Waste Policy Act of 1980, the State of Illinois adopted the Low-Level Radioactive Waste Management Act. The purpose of this act was to establish a comprehensive program for the storage, treatment, transportation and disposal of LLW in Illinois. The IDNS is the agency charged with carrying out the provisions of this Act.

The federal Low-Level Radioactive Waste Policy Act of 1980, established the policy that each state should be responsible for assuring disposal capacity for much of the LLW generated within its own borders. Under this legislation, states were encouraged to establish their own disposal facility or to form compacts with other states to develop regional disposal capacity. In 1984, Illinois joined with the state of Kentucky to form the Central Midwest Interstate Low-Level Radioactive Waste Compact (CMC). In 1987, the CMC designated Illinois as the host state for the disposal facility since 95 percent of the waste volume that will be disposed of in the facility comes from Illinois. Operating under a deadline of January 1, 1993 for the continued disposal of its waste out of state, IDNS has been working to establish a site for the CMC facility. As the January 1 date has passed, disposal of LLW out of state is still ongoing until June 30, 1994. A regional disposal facility may not be ready until 1999.

LOW LEVEL WASTE GENERATION

In order to present treatment, disposal and generation issues, it is important to understand the regulatory classification of low level radioactive wastes. Such classifications are an indicator of potential for radiation hazards. LLW is measured by its volume, consisting of the space occupied by the waste, binding agents and containers used for transportation and disposal. The radioactivity is measured in curies. A curie is the quantity of radioactive material that will produce 37 billion disintegrations per second.

Half-life refers to the time required for a radionuclide to lose one-half of its radioactivity by natural decay. The longer lived the substance, the lower the emission rate. To determine the degree of hazard, therefore the classification, it is important to identify the half-life, the type of radiation and the energy level.

The NRC established a classification system and a corresponding waste acceptance criteria for regulation of LLW. This system of classification was adopted under Illinois statutes. According to these regulations, LLW suitable for land disposal is placed in one of three categories: Class A, B or C. Class A wastes have the lowest radiologic hazards and class C have the highest. The greater the radiologic hazard, the more disposal safeguards apply to the waste. Wastes with a classification greater than Class C, would generally not be suitable for disposal in a LLW facility under federal law.

Number of LLW Generators in IL

The Illinois Low-Level Radioactive Waste Management Act (Ill. Rev. Stat. 1984, Supp., ch. 11 1/2, par. 241-1 et seq.) specifies that generators of low level radioactive waste in Illinois are required to submit an annual survey report providing information to the Illinois Department of Nuclear Safety (IDNS). A generator of LLW refers to an entity producing or possessing LLW in the course of manufacturing, conducting research, providing medical services, or pursuing other activities. Since 1985, generators of LLW in Illinois have been required to provide information about the types and volumes of LLW they stored or shipped for disposal each year. IDNS also requires information about waste treatment procedures or technologies used to reduce the amount of LLW. The survey information has been used by IDNS to produce annual reports of LLW generators. This information has provided a substantial basis for planning and regulatory initiatives related to LLW that have been undertaken in Illinois.

The IDNS assigns generators to categories based upon the activities that produce waste. The activities are grouped into the following categories: reactor, fuel-cycle, industrial, medical, academic and industrial.

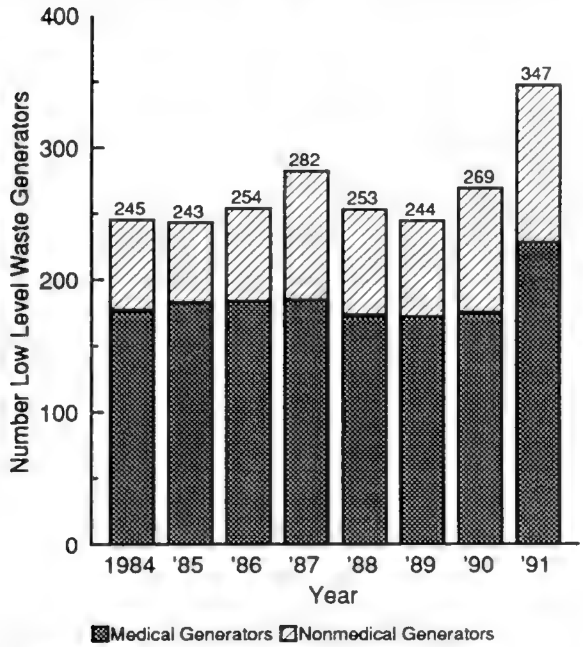
The reactor category consists of LLW produced by thirteen reactors operating at seven nuclear power stations locations. The LLW typically produced at nuclear power plants includes spent resins and filters, sludge, activated plant components and control rods, contaminated paper, glass, tools, protective clothing, wood and other trash. LLW typically generated by fuel-cycle facilities includes sealed radioactive materials used in gauges, product sterilization and industrial radiography, depleted uranium slag, contaminated piping, wiring and other hardware. Industrial LLW generators include private organizations that provide products or services to the private and public sectors. Radiopharmaceutical manufacturers and radiopharmacies are included in this category of LLW generators. These generators produce nearly all types of LLW. Medical facilities consisting of hospitals, medical centers, clinics, laboratories and private medical offices produce a variety of LLW. Low level medical waste consists of lab equipment, animal carcasses containing residual radioactive tracers, sealed radioactive sources used in cancer therapy and liquids. Academic LLW generators include both public and private universities. These facilities produce wastes similar to those produced by the medical generators. The governmental category includes LLW produced by city, state and federal governmental entities. This category also includes federal medical facilities such as Veterans Administration hospitals. These facilities generate nearly all waste types.

All operating reactor and fuel-cycle facilities are expected to ship LLW. A large percentage of medical generators hold their waste for radioactive decay, thus eliminating the need for LLW disposal. Some types of waste are produced by many types of generators. The most common types include: dry active waste composed of discarded paper products, cloth, plastic, wood, rubber and scrap metal; and air filters and air filter media and cartridges. On the other hand, some types of waste are characteristic of certain categories of generators. Activated hardware, for example, is a type of waste that is usually associated only with nuclear power reactors. This in effect determines the management options available to the generator.

Figure 8.1 shows that the total number of generators of LLW has increased from 245 to 347 since IDNS began the annual survey report. Most of these generators are considered medical generators. This increase in number of LLW generators is primarily attributed to an increase in the medical category.

Figure 8.2 displays the distribution of LLW generators across the state. The nuclear power facilities are specifically identified. Two reactor facilities are located in the Chicago area

Number of Low Level Waste Generators in Illinois 1984-1991



Sources: Illinois Department of Nuclear Safety Annual Survey Reports 1984-1991
Central Midwest Interstate Low-Level Radioactive Waste Commission Regional Management Plan (1988)

Figure 8.1

Non-medical generators include those from the following categories: fuel-cell, research, reactor, industrial, academic and governmental, other.

In 1984 nuclear power plants were counted by the number of utility companies and included in the fuel cycle category. In 1985 nuclear power plants were still counted by the number of companies, but were given their own category separate from other fuel cycle operations. The 1986 numbers reflect the number of power plants instead of the number of companies operating them.

Prior to 1985, there was a "research" category. The generators previously included in this category were regrouped under either the medical, industrial or the newly formed academic category.

Beginning with the 1990 IDNS Survey "other" was no longer included as a generator category.

(Commonwealth Edison: Zion and Braidwood). The remainder of the nuclear power facilities are spread throughout the northern and central parts of the state. The non-reactor generators are not broken out by category but the majority of them are medical and academic. Of 269 total generators in 1990, 158 are located in the Chicago area.

Volume of LLW Generated in Illinois

Because of its heavy utilization of nuclear power, Illinois is one of the largest producers and shippers of LLW in the country. According to data provided by the U.S. Department of Energy (DOE), Illinois ranked among the top 10 states with respect to the volume and curies of LLW shipped for disposal between 1984 and 1991.

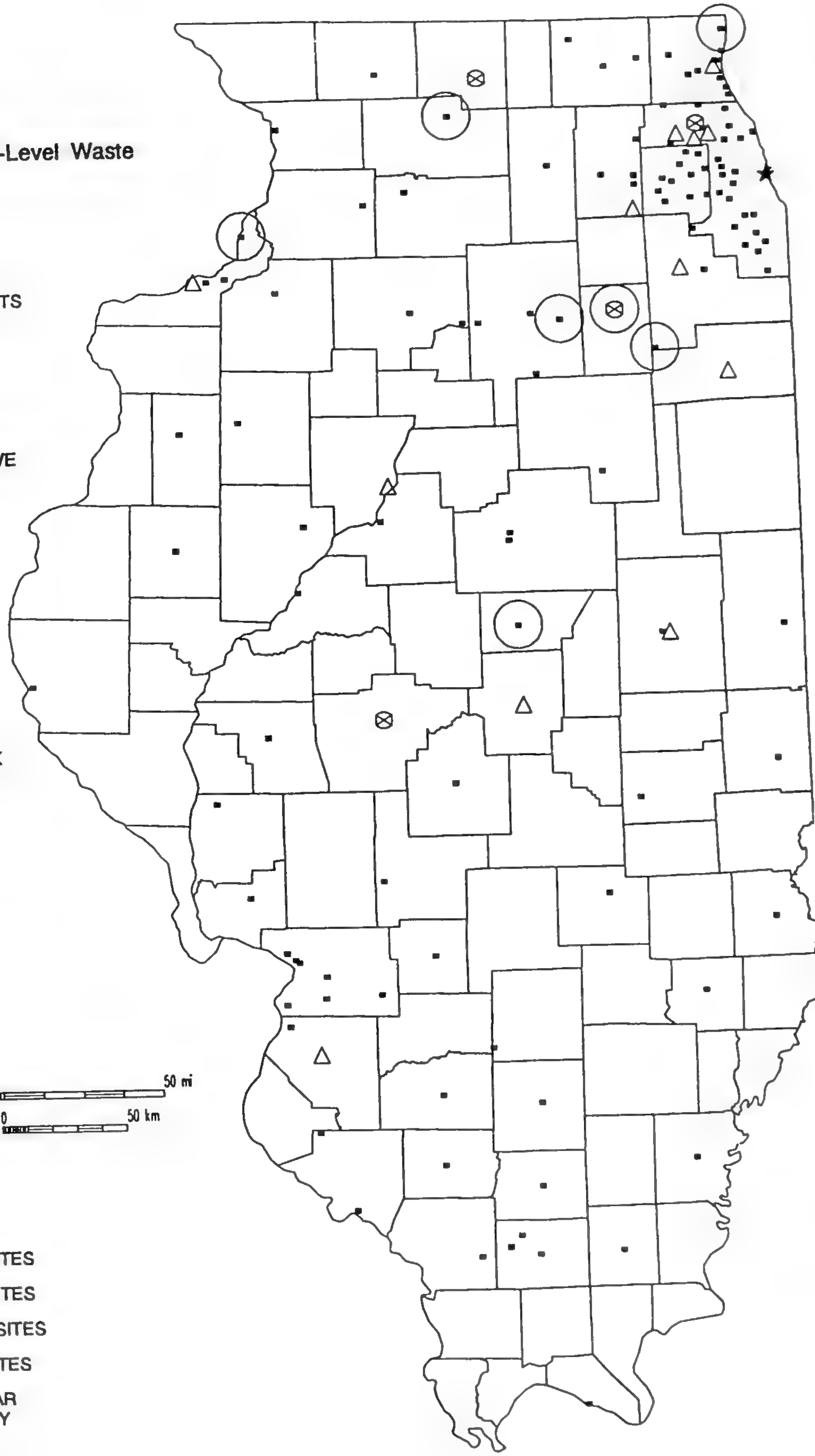
The annual survey conducted by IDNS has historically collected information on the volumes of waste generated and shipped by Illinois LLW facilities. Eight years of data are presented in Figure 8.3. It is apparent that the largest volume generators are from the reactor category. Volume fluctuations can be attributed to potential site closures and increases in fees.

Since data was first collected, initially by EG & G Idaho (for the federal government) and later by IDNS, it was evident that the nuclear power (reactor) industry is the predominant volume and activity generator category (Figure 8.3). In the early reporting years a larger portion of the total LLW stream could be attributed to the fuel cycle and governmental categories. In 1984, 70 percent of the volume was produced by the reactor category generators. In 1991, 93 percent of the volume was attributed to the reactor industry.

Since 1984, the total volume of LLW disposed at licensed facilities has decreased by 55%. The reactor volume during this period has decreased by 34% while adding seven reactors. While the volume being shipped from reactor facilities has increased, the overall disposal volume has decreased. The basic cost for final disposal has increased by more than 300% from 1984 to 1991, prompting utilities to find more economic methods for achieving greater volume reduction by sending LLW to processing facilities before final disposal.

Figure 8.4 shows the total radioactivity shipped from Illinois generators to LLW disposal sites during this period. The annual volumes are considered to be relatively stable except for non-routine circumstances. The curies shipped have radical fluctuations. These fluctuations are primarily due to maintenance and disposal of equipment and the shipment of materials previously kept in storage. Over 99% of the total radioactivity shipped in IL is from reactors.

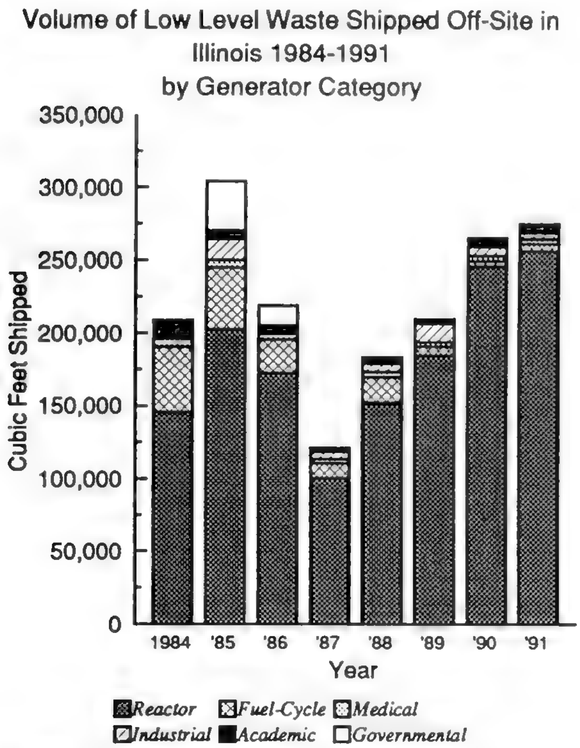
Figure 8.2
Cities with Low-Level Waste Generators



FREQUENCY
2 ALTON
6 ARLINGTON HGHTS
3 AURORA
4 BELLEVILLE
2 BLUE ISLAND
2 CARBONDALE
62 CHICAGO
3 DECATUR
3 DES PLAINES
2 DOWNERS GROVE
2 EAST ST.LOUIS
2 ELGIN
3 ELK GROVE VIL.
2 EVANSTON
2 GALESBURG
3 GREAT LAKES
2 HAZEL CREST
2 HIGHLAND PRK
2 HINSDALE
3 HOFFMAN EST.
4 JOLIET
3 KANKAKEE
2 MARION
2 MAYWOOD
2 MELROSE PARK
2 MOLINE
5 MORRIS
2 NAPERVILLE
2 NORMAL
2 OAK PARK
2 PALOS HGHTS
4 PEORIA
3 ROCK ISLAND
5 ROCKFORD
2 SKOKIE
8 SPRINGFIELD
3 URBANA
2 WAUKEGAN
2 ZION

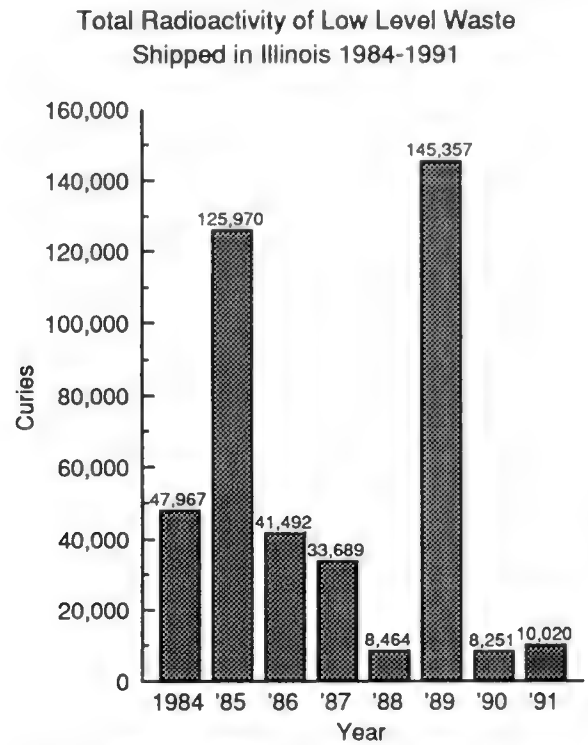
0 50 mi
0 50 km

LEGEND
▪ 1 - 2 SITES
△ 3 - 4 SITES
⊗ 5 - 10 SITES
★ 11 + SITES
◯ NUCLEAR FACILITY



Source: Illinois Department of Nuclear Safety Annual Survey Reports 1984-1991

Figure 8.3



Source: Illinois Department of Nuclear Safety Annual Survey Reports 1984-1991

Figure 8.4

LOW LEVEL WASTE MANAGEMENT

Disposal

There are three commercial disposal facilities which have accepted Illinois low level wastes: Barnwell, SC; Richland, WA; and Beatty, NV. These disposal facilities receive shipments directly from generators and from intermediary firms that may treat, consolidate and repackage waste. No commercial facilities are expected to be available to Illinois low level waste generators after June 10, 1994.

Storage On-Site for Decay to Background Levels

One of the alternatives to off-site disposal is storing short-lived LLW on-site until the radionuclides decay to background levels. This generally means storing the waste and re-evaluating it after ten half lives, to ensure radiation levels are at background levels. All or a portion of the stored waste may then be disposed of as non-radioactive waste. This is a common practice for medical, industrial, academic and governmental generators.

Treatment and Reduction of LLW

Generators use various treatment techniques to reduce the volume of waste being shipped or stored. The motivation for on-site treatment and reduction is usually one of cost. Due to the rising costs associated with disposal and handling of LLW, it is desirable for many generators to reduce the volume and radioactivity of the waste prior to shipment.

In 1991, 347 generators reported using on-site treatment and reduction technologies to reduce the volume of waste being shipped or stored. Dewatering, standard compaction and solidification of wastes are the predominant on-site treatment methods used by Illinois generators for wastes shipped directly for disposal. Wastes that will be shipped to an intermediary may be processed using different treatment and reduction methods since waste often receives additional treatment prior to disposal. According to the IDNS 1991 annual survey, common waste reduction methods employed by LLW generators relate to segregation and sorting of materials. These methods are relatively inexpensive to implement, but yield considerable savings to the generator.

The application of volume reduction techniques can lead to significant reductions in the demand for low level waste management capacity. For example, IDNS reports that in 1989, final disposal of reactor generated waste volumes decreased from 184,557 cubic feet to 114,122 cubic feet. For more information relating to low level waste generation by reactor generators, see the CTAP volume on *Sources of Environmental Stress.*

Unnecessary contamination of tools and other articles can be avoided by restricting the number of articles allowed to enter contaminated areas. Similarly, limiting the number of areas within a facility in which radioactive materials can be used will also minimize unnecessary contamination of materials. Sorting of waste by radionuclide, half-life or activity enables generators to segregate materials according to the manner in which they must be handled and disposed. Such sorting techniques may be as simple as providing separately marked trash barrels for wastes that can be stored for decay, those that can be incinerated and those that must be shipped for disposal. Other techniques for treatment and reduction are listed in Table 8.1.

In 1991, ten Illinois generators from the medical, academic and industrial categories employed on-site LLW incineration. Incineration of radioactive contaminated waste is allowed under state and federal law. The resulting ash may or may not require handling as a low level radioactive waste depending upon the nuclides contained in the waste. Within limits allowed by law (32 Ill. Adm. Code 340.3050) quantities of certain radionuclides may be vented from the stack during incineration. Those radionuclides that do not volitize will be found in the incinerator ash. It is unusual for incinerator ash to be sent for disposal since the ash is usually held for decay to background levels.

While the opportunity for treatment and reduction may be limited by the type of LLW, cost and availability of treatment or reduction options may have a substantial impact on the volume of waste requiring disposal. For example, in 1989, of the 244 registered LLW generators in Illinois, only 56 (22 percent) shipped LLW for disposal or processing. Many generators, especially hospitals, employ storage for decay because of the nuclides they utilize. Because of the cost and space, almost all generators that generate LLW for disposal, including reactors, send waste to commercial brokers and processors for treatment and reduction techniques. Smaller generators tend to hold waste for shipment and therefore may ship waste on an annual basis.

Table 8.1. LLW Treatment and Reduction Methods

abrasive cleaning	incineration
adsorption	article or area limitation
adsorption	recycling
baling	shredding
chemical extraction	solidification
compaction	standard compaction
decontamination	stripable coatings
dewatering	substitution of non-radioactive techniques
electropolishing	supercompaction
evaporation	washing
high-pressure water cleaning	extraction through ion exchange
use of non-hazardous water-miscible scintillation fluids	filtration

As with other waste types, LLW disposal problems may be reduced through the utilization of waste reduction and minimization technology. It is evident that non-reactor generators have reduced the amount of waste they produce through the application of segregation practices and substitution of materials. All generators are seeking new cost effective ways to reduce their volume further.

SOURCES

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MINERAL EXTRACTION WASTE

Wastes from Coal Mining

Lisa R. Smith
Illinois State Geological Survey

Coal mining by surface and underground methods has been practiced in Illinois (fig. 9.1) for more than 180 years. Although the economic benefits of mining have been great, it has greatly modified the surface of some areas of Illinois. Of all the earth materials disturbed to recover coal, it is estimated that approximately 70% is potentially recoverable coal and 30% is noncombustible waste (S.B. Bhagwat, ISGS, personal communication Bhagwat 1993). Previous estimates of noncombustible waste were as high as 50% (Nawrot et al. 1977). In 1991 alone, more than 18 million tons of coal-related waste was generated in Illinois. (Estimated are based on production statistics.) In the past, disposal of this waste has been on-site, conspicuous, and consequential. Regulations in effect since the 1960s have significantly influenced the disposal of wastes related to coal mining and made it less conspicuous and less consequential.

Regulations

In 1962, Illinois' first mining reclamation law, the Open Cut Land Reclamation Act, went into effect (Klimstra and Jewell 1973). This act required a permit to remove overburden in excess of 10 feet thick and was the first to require reclamation and bonding of disturbed lands. Reclamation laws specific to mining wastes have become more demanding through the years. In 1968, the Surface-Mined Land Reclamation Act (SMLRA) was passed in Illinois; it required that mine waste be covered with 4 feet of material capable of sustaining vegetation and that a cover be established (Illinois Department of Conservation 1968). In 1972, in response to increased awareness of health, safety and environmental impacts of mining, the Illinois Pollution Control Board Regulations, Chapter 4 – Mine Related Pollution, implemented environmental controls for the planning, location, operation, and abandonment of refuse areas (Nawrot et al. 1982). By 1977, the federal Surface Mining Control and Reclamation Act (SMCRA) was passed, setting up a permitting system with detailed mining and waste reclamation standards for coal operators. This legislation led Illinois to pass the 1980 Surface Coal Mining Land Conservation and Reclamation Act (SCMLCRA), which enabled the state to enforce the federal laws (SMCRA) and to fund the Illinois Abandoned Mined Lands Reclamation Council (AMLRC). The AMLRC is charged with acquiring and reclaiming abandoned mine waste sites.

Acreage Affected by Mining

More than 250,000 acres have been affected by surface and underground mining of coal throughout the state (Illinois Coal Association 1993). Of these, approximately 103,000 acres were disturbed before the 1962 mining legislation; wastes deposited and abandoned during this time were not subject to reclamation treatment of any kind. Between 1962 and 1977, approximately 84,000 acres were disturbed and the wastes deposited during this time were subject to increasingly restrictive regulations. Since 1977 and the implementation of SMCRA, approximately 68,000 acres have been disturbed and all of the wastes disposed of on these acres have been subject to the strictest reclamation laws.

Prelaw and Postlaw Wastes

Coal mining wastes are divided into two categories, prelaw and postlaw, according to the chronology of the passing of the rules and regulations pertaining to them. Although the Illinois Department of Mines and Minerals (IDMM) and some of the literature suggests that 1962 is the division point, the AMLRC considers abandoned lands mined before 1977 to be prelaw, as they are eligible for reclamation under AMLRC's mandate.

The total disturbed acres were inventoried for the AMLRC in 1980 by the Cooperative Wildlife Research Laboratory at Southern Illinois University at Carbondale (SIU–C). Portions of approximately 22,500 acres were covered with pre-1977 coal waste products: 6,500 acres of abandoned preparation wastes, 4,300 acres of slurry, and 11,700 acres of abandoned spoilbanks and tipple sites (Nawrot et al. 1977, Nawrot et al. 1982). Of the total pre-1977 acreage eligible for reclamation by the Illinois Abandoned Mined Lands Reclamation Council, 8,582 acres have been reclaimed (Nutt 1992). These include 2,658 acres associated with surface mining operations (spoil) and 4,936 acres of refuse associated with wash plants, cleaning operations, and unwanted waste rock (AML 1992).

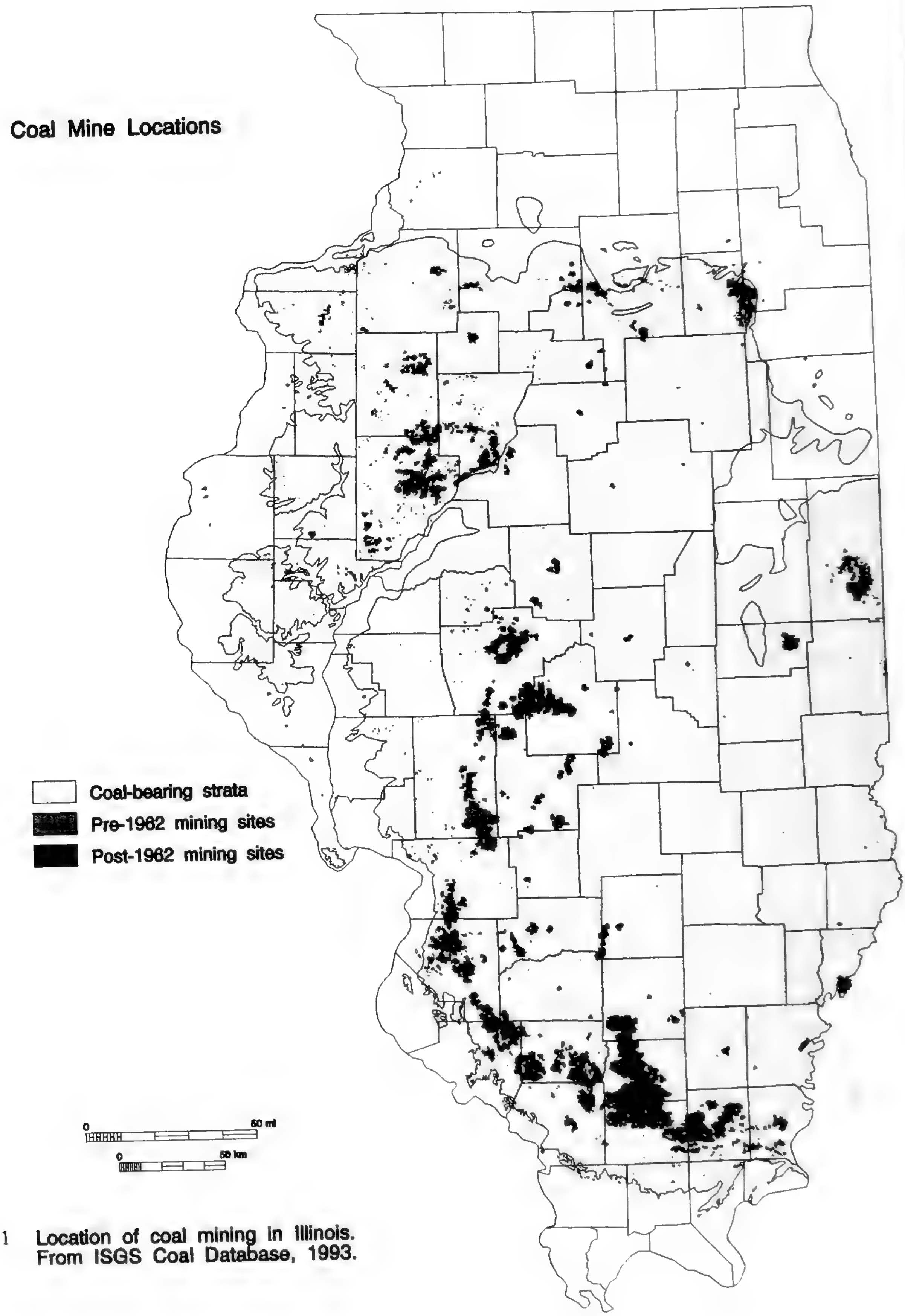

Figure 9.1 Location of coal mining in Illinois. From ISGS Coal Database, 1993.

The AMLRC prioritizes sites to be reclaimed on the basis of public health and safety hazards and on the site's potential to substantially degrade the quality of the environment. Approximately 9,000 eligible acres of prelaw wastes are still exposed to weathering that may break them down and release contaminants through erosion and runoff.

Post-1977 mine operators are required to have a reclamation plan as part of the permitting process and be responsible for carrying it out. With the implementation of the environmental regulations listed above, post-1977 mining operation waste sites, unlike remaining pre-1977 waste sites, should not pose serious risks to Illinois's environment. To enforce these laws, IDMM inspects these mining operations for infractions of standards set by SMCRA to protect the environment. A total of 147,718 acres has been affected by surface mining of coal since the 1962 regulations began. Of the total, approximately 74,000 acres have been reclaimed and bonds released under various laws (IDMM 1990).

Mining Wastes

Waste disposal associated with coal extraction, both surface and underground mining, occurs at the mine site. Waste associated with the extraction of coal consists of spoil at surface mines and roof and floor waste piles (unwanted waste rock) at underground mines. Additionally, both pre-1977 surface and underground mine sites can contain abandoned buildings and equipment, generally associated with inactive loading tipples (Nawrot et al. 1982).

Spoil

The overburden materials removed from above the coal seams at surface mines are termed "spoil." Spoil associated with post-1977 mines is redeposited over the mined-out area and poses no risk. Pre-1977 standing spoil banks that appear as a series of parallel ridges or banks, some more than 20 feet high, may be in need of reclamation. Spoil materials vary in chemical properties and texture. The relative proportions of different kinds of rock and the particle sizes, texture, and aggregation of the spoil material will promote or prevent revegetation of the spoil bank (Nawrot et al. 1982). Because a considerable portion of the spoil in Illinois is glacial in origin (pebbly clay) and rarely toxic (IDMM 1991), many of the pre-1977 unreclaimed spoil banks are at least partially revegetated. Some remain unvegetated, however, not only because they have low soil pH values and high concentrations of soluble salts (aluminum, calcium, iron, and rarely, manganese and zinc), but also because they lack essential plant nutrients and/or contain toxic elements that discourage vegetation (Nawrot et al. 1982).

Roof and Floor Wastes

Underground mining produces a waste pile comprising unwanted roof and floor materials. This pile is sometimes referred to as "gob," although the term is somewhat confusing because gob piles are more commonly associated with coal cleaning or processing. Earth materials discarded during the mining operation make up this gob, which consists of shale, underclay, concretions of pyrite or various oxides or carbonates, and other kinds of waste rock hauled up and removed from the coal mine (Bradford et al. 1987). Many of these gob piles remain at unreclaimed, pre-1977 underground coal mining sites.

Abandoned Buildings

Abandoned surface and underground mine sites usually include buildings that housed coal washing, storage, and loading structures (tipple sites), and abandoned machinery and equipment. Left to succumb to the elements, they take on the look and hazards of an abandoned landfill. Problem sites as large as 40 acres have been documented, although most sites are smaller (Nawrot et al. 1982). Many pre-1940 underground mines have few remaining buildings, but they do have potentially hazardous mine openings (Nawrot et al. 1982, Bradford et al. 1987). Pre-1977 mines from the 1950s and 1960s pose the greatest concern because they have many abandoned structures and pieces of equipment.

Since 1977, mine operators have been required to reclaim mine sites to their original contour and land cover and to dispose of all buildings and machinery. Before mining begins, operators are required to post bond with the state. If the operator fails to reclaim the site within a specified time, the State will use the bond money to complete the reclamation, including the removal of machinery.

Processing Wastes

Processing wastes may be generated either at the mine site or at some central processing plant location. Almost all post-1977 Illinois mines either have a coal processing plant on-site or nearby, or they haul raw coal directly to the customer. In the past, a few operators have hauled coal to a separate central processing plant.

During the natural formation of coal, many noncarbon impurities are entrapped within the coal seam. Impurities, some of which are potential pollutants, in the coal seam are metal sulfides (e.g. pyrite) and layers of shale. Most coal mined in Illinois is cleaned to minimize these value-reducing portions of the raw coal. Coal cleaning results in two kinds of wastes: gob and slurry. Gob is coarse waste material and slurry is fine refuse. Unreclaimed processing gob and slurry sites are associated with prelaw surface and underground mines.

Gob Processing gob consists mostly of rock fragments that are denser than coal and separated from coal in the cleaning process. The composition and texture of processing gob varies because of differences in the mining technique, seam mined, and the type of coal preparation and disposal method. Coarse refuse contains varying percentages of shale, other rock types, and small amounts of coal. Gob piles compact to varying degrees after deposition and commonly have poor soil moisture-retention characteristics. Chemically, preparation gob contains a high percentage (up to 10%) of pyrite (iron sulfide), which upon weathering, produces acidic conditions (runoff containing sulfuric acid) and associated high concentrations of metallic ions and soluble salts. The low pH and associated high concentrations of soluble salts are toxic to plants and commonly inhibit or prevent reestablishment of vegetation on the gob pile (Nawrot et al. 1982). Pre-1977 gob piles may cover up to 300 acres and can exceed 100 feet in height. The terraced or cone-shaped piles, if unvegetated, may be unstable and susceptible to erosion (Nawrot et al. 1982). Post-1977 gob piles must be reclaimed and should not pose long term risks.

Some of the first piles of mine gob or refuse contained enough coal to catch fire. Since 1977, the AMLRC has dealt with 13 fires in gob or refuse (Association of Abandoned Mine Land Programs [AAMLP] 1992). What causes spontaneous combustion of the piles is not fully understood, but combustion changes the chemical nature and texture of the gob. During spontaneous combustion, clay-rich material is altered to clinker, a hard brick-like mass. The variable chemical composition of clinker depends upon the composition of the pile and the temperature to which the pile was heated (Nawrot et al. 1982, Bradford et al. 1987).

Slurry The other byproduct of the coal cleaning process consists of fine grained solids suspended in water. Slurry is usually pumped through pipeline to a settling pond or dewatering impoundment. The small particle size, uniform texture, and lack of cohesiveness results in extreme susceptibility of the dried material to wind and water erosion. Chemically, slurry is similar to gob, although it contains much more coal and is characterized by low pH, high conductivity, and phytotoxic concentrations of soluble salts and metallic ions (Nawrot et al. 1982). Slurry impoundments can cover many acres. Abandoned pre-1977 impoundments range in size to 280 acres. Post-1977 slurry impoundments can be equally as large. Slurry impoundments associated with underground mines were often contained within gob or combination gob/earthen embankments. In surface mines, slurry disposal often utilized final cuts, inclines, and depressed areas between spoils for containment (Nawrot et al. 1982).

THE ENVIRONMENTAL RISKS OF WASTE DISPOSAL

The nature and environmental consequences of coal mining waste have been well documented in Illinois. As mentioned, Illinois coal mining-related laws are intended to protect the environment. Regulations exist to manage potential pollution from waste disposal at postlaw mines. Although environmental degradation occasionally occurs in relation to postlaw mining, most environmental problems are associated with prelaw abandoned sites. Abandoned mine waste refuse piles and unreclaimed spoil represent potential sources of air pollution, erosion, and runoff (sedimentation), water pollution, and aesthetic degradation.

Air Pollution

Where there is little or no vegetation to hold down materials on waste pile slopes or dry slurry ponds, wind can easily erode materials and carry them to adjacent lands (Bradford et al. 1987). When surface material is disturbed and dries out, it can become a nuisance. According to Nawrot et al. (1982), airborne particulates from barren or sparsely vegetated gob piles or spoil banks (generally clayey in nature) can prevent the exchange of gases by plants, interfere with pollination, increase susceptibility to disease, and bruise plant tissue. Thicker deposits of the windblown material can affect productivity of agricultural lands and even clog farm machinery (Bradford et al. 1987); however, these phenomena have not been common in Illinois. Airborne pollution from spontaneous combustion in coal waste is also not a significant problem in Illinois; it is usually local in effect. Burning gob can release significant amounts of CO, SO_2, H_2S, nitrogen oxides, hydrocarbons, and particulates (Nawrot et al. 1982), however, and thus threaten the health of the local population, restrict visibility, harm vegetation, corrode materials, and reduce aesthetic values (Sussman and Mulhern 1964, McNay 1971, Nawrot et al. 1982). Once this burning starts, it is difficult to stop. Of less concern is the risk of spontaneous combustion of abandoned prelaw gob piles at active mines.

Sedimentation

Spoil banks and gob piles that are unstable and/or unvegetated are subject to severe erosion and runoff that can result in the accumulation of silt-size sediment in low lying areas such as bottomlands, standing surface waters, wetlands, and streams. For example, silt-size sediments eroded from gob piles and spoil banks can fill in streams and cause flooding on lands that use the streams for agricultural drainage. Fields may become too wet to farm and other problems associated with flooding (such as water in basements) may occur (Bradford et al. 1987). The sedimentation of low-lying areas could result in the loss of lake, wetland, or stream ecosystems. Sedimentation associated with prelaw extraction sites has been a serious problem in Illinois (Nawrot et al. 1982).

Water Pollution

Damage to streams and surface waters from runoff at prelaw refuse areas is well documented in Illinois (Nawrot et al. 1982, Energy and Environmental Analysis 1978 Haynes and Klimstra 1975). Sources of runoff include mined areas or spoil piles, poorly contained gob piles, and improperly operated or abandoned slurry ponds. Gob and, to a lesser extent, spoil banks contain varying amounts of pollutants, especially acid-generating compounds (sulfur-bearing compounds such as pyrite) (Energy and Environmental Analysis 1978, NAS 1978). Sulfur-bearing compounds in the gob or spoil react with oxygen in the air and form sulfuric acid, which then leaches out of the piles and enters adjacent waters through runoff and seepage. This acid drainage can also contain iron and other compounds that, if not properly controlled, degrade water quality. Severe effects from these acid-generating compounds are less common in Illinois than in other states because the overburden contains large amounts of carbonates that neutralize the acid. Where acid drainage occurs, however, it is especially problematic because it forms a self-perpetuating cycle of oxidation, leaching, and erosion (Energy and Environmental Analysis 1978).

Slurry impoundments associated with prelaw coal cleaning operations present similar problems. A significant amount of coal remains in the slurry materials. Along with its associated compounds (pyrite), this coal refuse can be a source of acidic drainage. Seepage or overflow from poorly maintained or unlined impoundments can expose ground or surface water to the same compounds (Energy and Environmental Analysis 1978, Narwot et al. 1982).

Aesthetic Degradation

Disturbed lands appear in coal-producing areas throughout the state. They are lands affected by overburden removal or deposition, mineral processing sites, mineral storage sites, or transportation (IDMM 1991). What is offensive to some, however, may be interesting to others. Scenic vistas associated with disturbed areas have proven attractive for development of recreational homesites, sportsman's clubs, recreational clubs, and state parks. Several pre-1977 mining areas have become popular public parks; for example, the effigy site at Buffalo Rock State Park in La Salle County, Kickapoo State Park in Vermilion County; and Pyramid State Park in Perry County.

CURRENT STATUS AND THE ENVIRONMENTAL IMPLICATIONS

Reclamation Laws

Congress passed laws, such as the SMCRA of 1977, which set minimum standards for both surface and underground coal mining operations, particularly regarding the effects of mining on the earth's surface (Illinois Coal Association 1992). The laws are the result of private citizens and government recognizing the need to regulate mining activities that have the potential to adversely affect the environment.

The result was to put coal mining companies on the same level so that the cost of reclamation and pollution control would be built into the cost of all coal marketed by producers. Coal companies must now reclaim all waste byproducts at post-1977 mine sites. Disturbed areas must be restored to productive land or to their premining status. The SMCRA also established a reclamation fund to finance the restoration of land that was mined prior to August 1977.

These reclamation laws eliminate most long term impacts of current coal mining waste disposal; however, short term impacts may still occur during the life of a mine and use of a processing site. The IDMM enforces the mining laws and issues notices of violations when they are discovered. To minimize the potentially harmful impacts of coal mining, for example, inspectors monitor stripping operations to ensure (1) that topsoil is removed, replaced at the proper thickness, and protected from erosion; and (2) that water quality and impoundment stability are checked for compliance.

Reclamation Activities

In 1980, an inventory of mined lands was prepared by the Cooperative Wildlife Research Laboratory (SIU–C) for the Illinois Abandoned Mined Lands Reclamation Council. It supplied basic data for a state reclamation plan for abandoned mined lands, as required by the SMCRA. Only 10% of all the land affected by mining was identified as problem areas. Since then, a significant portion of the pre-1977 mines have been reclaimed; however, approximately 9,000 acres are still in need of some reclamation (Nutt 1992).

Effective reclamation requirements from SMCRA have no doubt resulted in eliminating the long term problem of spoil banks and waste sites at post-1977 mines. Faced with stringent legislation, industry and regulatory agencies conducted the research necessary to devise and implement effective reclamation techniques. During the 1980s, everyone responsible for the success of these measures was on a steep learning curve. Now that there is agreement about what works for reclaiming mined lands, the results of future reclamation projects are likely to be excellent (H.H. Damberger, ISGS, personal communication 1993).

Environmental Impacts

Erosion and runoff from unreclaimed, abandoned coal refuse areas, the legacy of pre-1977 mining, have made the most impact on the environment. Conditions likely to be found at gob sites and other unreclaimed refuse areas include instability and erodibility of the refuse material, high surface temperatures (which discourage revegetation), inadequate soil moisture, nutrient deficiencies, and phytotoxic conditions. On large gob piles, the unfavorable conditions will continue to inhibit or limit plant growth (Nawrot et al. 1982). An estimated 30% of the unreclaimed prelaw acreage remains in this condition (AMLRC 1993). Most older, smaller refuse areas with thinly scattered gob have revegetated and show little or no evidence of past mining activities. Where revegetation has been inadequate, erosion has resulted in stream and surface water pollution (Nawrot et al. 1982). Many past impacts have been recorded in studies related to coal and water pollution (Hall 1962, Lopinot 1973, Klimstra and Terpening 1974, NAS 1978, Nawrot et al. 1982).

At post-1977 mines, companies offset loss or destruction of streams and wetlands by better prevention and treatment of acid runoff. Compliance is ensured by monitoring of surface water associated with mining sites, as required by the IEPA and regulations in Title 35: Environmental Protection, Illinois Administrative Code Subtitle D, which regulates surface monitoring under the National Pollutant Discharge Elimination System (NPDES). New studies are needed to document the affect of current mining practices.

Windblown particulate matter associated with dry slurry surfaces produced before 1977 may contribute to adverse off-site impacts. Usually, these impacts are localized and cause little concern outside the immediate area. If prelaw impoundment embankments are intact and water is retained on the slurry surface, conditions are often suitable to support vegetation.

Prelaw tipple sites remain a problem, although some have been turned to good use; for example, some tipple areas have been converted to salvage yards (Nawrot et al. 1982).

Secondary Recovery

The environmental impact of the fine material in slurry impoundments may be offset by the economic opportunities. Processing coal leaves a fine component that ends up in a slurry impoundment and makes up approximately 40% of the total waste associated with coal extraction. The loss to coal production is significant. This waste contains 40 to 55% coal fines—3% to 5% of the total coal extracted from a mine. If recovered, this coal would be comparable in heating value and ash and sulfur content to coal products currently sold.

Modern extraction methods produce even more coal fines than did past mining practices. The potential economic gains from the recovery of a clean, high-value coal product, in contrast to the costs associated with the disposal and reclamation of this fine material, may present an economic incentive for coal companies to develop better methods for recovering and using the coal portion of the waste. Recently, market conditions made it economically feasible to recover fine coal during the cleaning process (Bhagwat et al. 1989). If the market holds, waste disposal of fines is expected to be significantly reduced in the future. Secondary recovery or reduction of this coal slurry could result in preservation of 20 to 30 acres of land surface now taken for ponding each year (Bhagwat et al. 1989). According to coal mine permit records and the IDMM, more than 12 "carbon recovery" operations are now mining previously abandoned refuse areas. These secondary recovery sites are being reclaimed as they are mined-out (Bhagwat et al. 1989).

TRENDS

The trend in production and disposal of wastes related to coal mining has been stable for the last 20 years. Coal production may decline in the future, and in turn, the production of wastes will decrease. The consequences of waste disposal have decreased since 1977 because current law prohibits disposal without reclamation and past wastes are being reclaimed under provisions of the 1977 Surface Coal Mining Land Conservation and Reclamation Act.

There is an economic incentive for coal companies to maximize productivity by recovering as much of the coal from the fine waste component as possible. Although the coal is expensive to clean, studies at the ISGS indicate this material is a potentially valuable product that could command market price. The reduction in the quantity of fines deposited in slurry ponds would be significant in the future.

Mining of slurry ponds should increase over the next 30 years despite the recent drop in the number of mine permits for this activity. This is an example of secondary recovery of an economic mineral for the benefit of industry and the subsequent reclamation of the site for the benefit of the environment.

The amount of acreage disturbed annually by surface coal mining continues to decrease as the resources suitable for surface mining continue to be depleted. The amount of prelaw disturbed acreage that is unreclaimed is also decreasing. The funding that supports this work by the AMLRC will no longer be available after the year 2000.

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Wastes from Noncoal Mining Activities

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For more than half a century, Illinois has ranked among the top 20 states in the value of minerals produced annually. Many minerals other than coal are produced in Illinois: sand and gravel, microcystalline silica (tripoli), ganister, novaculite, silica sand, stone, clay, shale, peat, and fluorspar (fig. 9.2). Small amounts of secondary minerals associated with fluorspar have been recovered, including barite, calcite, lead, silver, and zinc (Sherrill et al. 1991). Direct mining of lead and zinc, primarily in northwestern Illinois, peaked in the 1850s, and most of these mines were closed by 1975.

Historical and current recovery of noncoal minerals has been documented at 1,870 sites across the state (Sherrill et al. 1991). Not well documented, however, has been the generation and management of mining wastes at these sites. The following discussion was compiled from mining-related literature, reports from the Committee on Surface Mining and Reclamation – National Academy of Science (COSMAR – NAS), reports of the Illinois State Geological Survey (ISGS), and written information from the Illinois Department of Mines and Minerals (IDMM) as well as personal communication with IDMM, the Illinois Abandoned Mined Lands Reclamation Council (AMLRC), and the Illinois Environmental Protection Agency (IEPA).

It is uncertain how many acres were affected by noncoal mineral extraction because the activity was unregulated for many years. Of the statewide inventoried sites, between 450 and 700 (as of 1993) are active, noncoal, mineral extraction sites; all but a few are either limestone quarries or sand and gravel pits (Sherrill et al. 1991; IDMM 1991). Most of the noncoal minerals are extracted from quarries or pits in Illinois. Sand and gravel, silica sand, stone, tripoli, clay, shale, peat, and some fluorspar are all quarried or surface mined from pits. Tripoli, most fluorspar, and some stone are mined underground. In the early days of mining in northwestern Illinois, lead was extracted from shallow deposits. However, in general lead, fluorspar, and its secondary minerals were historically mined underground.

According to the U.S Bureau of Mines (USBM 1990), there is a general trend toward reduction in mineral production in Illinois. The exception is aggregates production. Therefore, there should be an overall reduction in mine wastes that require disposal, again with the exception of disposal associated with aggregates. Records of waste disposal tonnage are not required by permitting agencies, so no permanent record is available. Although the amount of waste resulting from noncoal mineral extraction may be estimated from production statistics, the estimates are likely to be inaccurate, as some mineral production data are proprietary and thus unavailable (S.B. Bhagwat, ISGS, personal communication 1993). The IDMM estimates that for most mining sites, less than 20 acres is affected during the life of a mine. Given the general nature of mining in Illinois, one can assume that the amount of solid waste generated from extraction and processing of noncoal minerals in Illinois is comparatively small. The IDMM estimates, based on mine waste permits issued during the last 20 years, that acreage affected by noncoal extraction waste disposal is about 500 acres. Of these acres, about 250 are currently in use, primarily as slurry ponds (IDMM 1991).

Mining wastes are generated by two separate processes, mineral extraction and beneficiation. Extraction waste generally consists of overburden and some waste rock. The overburden (soil or other geological materials lying over a mineral deposit) must be disturbed from a natural state to recover the mineral. Waste rock is the oversized, reject component resulting from crushing, sizing, and separation of minerals; it is usually heaped near the processing site (Sherrill et al. 1991). Beneficiation is the process of separating ore minerals from associated non-ore minerals by crushing, grinding, and washing. Beneficiation waste consists of coarse grained waste rock and fine grained tailings, slurries, and slimes (waste waters managed in surface impoundments). Tailings, defined as the fine mineral processing reject, are usually transported as a slurry of solids and process water to an impoundment for dewatering and disposal (Sherrill et al. 1991, Office of Technology Assessment 1992).

Additional wastes associated with mineral extraction and processing include ordinary garbage, construction debris, abandoned buildings (hazardous structures), and discarded equipment (NAS 1979). Ordinary garbage and construction debris are deposited in on-site or other approved landfills. Little information is available concerning abandoned buildings and processing structures that pose environmental and safety concerns. These potentially hazardous structures are

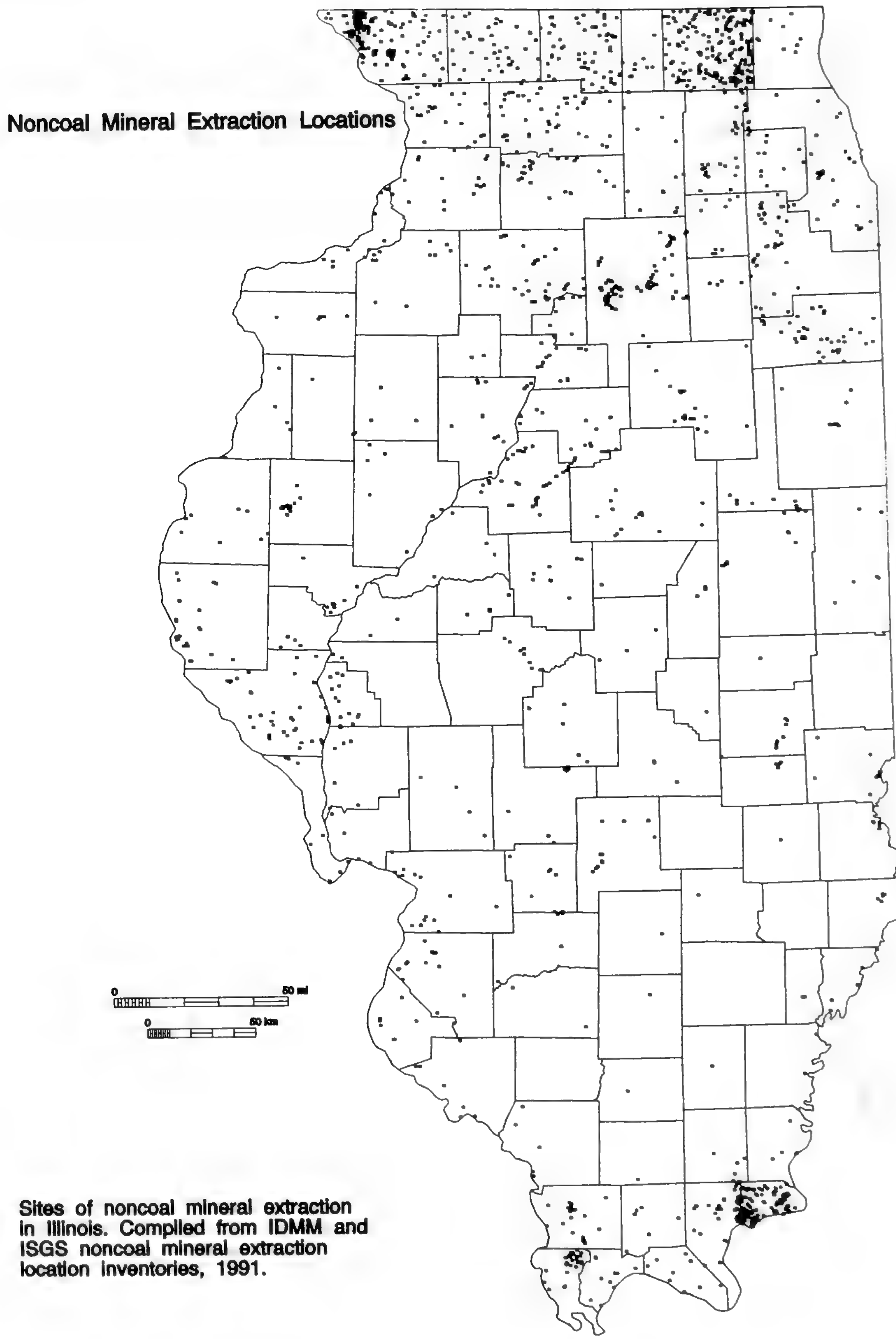

Figure 9.2 **Sites of noncoal mineral extraction in Illinois. Compiled from IDMM and ISGS noncoal mineral extraction location inventories, 1991.**

not regulated.

Sites where mining wastes are deposited or where slurry impoundments are placed are sometimes called mine dumps. The selection of a disposal site is generally dictated by the mine location, local topography, chemical properties of the waste, and the surface and groundwater flow systems. Plans for use of the land after mining ceases may also be taken into consideration, since passage of the Open Cut Land Reclamation Act of 1962 and the Surface Mined Land Conservation and Reclamation Act (SMLCRA) of 1977. Although support areas such as processing and storage areas are not subject to reclamation regulations (IDMM 1991), any land associated with mining and affected by overburden removal or deposition, mineral processing or storage, or the location of mine dumps is considered disturbed land.

The disposal of mining waste can affect the land surface (through land use and aesthetic degradation), surface water, groundwater, and air. Evidence in Illinois of the effects of noncoal mining on these environmental elements is not well documented. In 1991, the IDMM inventoried locations of noncoal mining sites in Illinois but did not inventory solid waste disposal practices or types of wastes on a site-specific basis; nor did they assess the environmental consequences of waste management at these sites.

THE ENVIRONMENTAL RISKS OF WASTE DISPOSAL

Almost every stage of mining presents some potential risks to the environment, depending on the mining technique, composition of the ore, nature and thickness of the overburden and topsoil, topography, surface and subsurface hydrology, climate and reclamation practices (Tank 1983). These factors apply also to the deposition of wastes associated with mining. Overburden, waste rock piles, and slurry impoundments represent potential sources of air pollution, sedimentation, water pollution, and aesthetic degradation (OTA 1992, Tank 1983, Piskin et al. 1980, NAS 1979). The potential environmental consequences from mine waste disposal range from negligible to serious and depend on site-specific factors (OTA 1992). The specific risks associated with wastes from the noncoal mineral extraction and processing industries in Illinois can only be determined through investigation. However, some general observations regarding potential environmental effects can be gleaned from existing literature.

Air Pollution

Mineral deposits vary greatly in composition, although sand, gravel, and limestone generally consist of inert, nontoxic materials. The U.S. Environmental Protection Agency (USEPA) now recognizes that the presence of silica dust may represent a significant health hazard to workers (J.H. Goodwin, ISGS, personal communication 1993). Processing such materials so as to prevent environmental damage consists mostly of controlling dust produced during crushing and grinding (Cameron 1986). The waste piles and tailings associated with these inert minerals are fairly benign. Other minerals, such as fluorspar and its associated elements (zinc, silver, sulfur) and minerals (lead, sphalerite, pyrite), may produce more toxic mine wastes and tailings. Formal studies are needed to document the air pollution potential of the noncoal mineral industry in Illinois.

Sedimentation and Water Pollution

Overburden and waste rock are commonly stored in a heap or pile near the mine or processing site. If the overburden and waste rock piles have a toxic constituent and are exposed to oxygen and moisture, the toxic element can be mobilized in surface and groundwater. Where precipitation is sufficient and the waste materials are fine grained, uncontrolled runoff from piles of these materials can result in silting of streams. In either event, the result is contamination of groundwater and degradation of aquatic ecosystems (OTA 1992). Such conditions may exist because of noncoal mineral extraction in Illinois, but they are not documented. Releases from impoundments and tailings ponds at noncoal mineral extraction and processing sites have generally been of great concern at the national level (OTA 1992). The USEPA has documented environmental damage and concluded that releases from failed impoundments, loss of liner integrity, pond overflow, and seepage at both active and inactive sites have contaminated water resources (OTA 1992). However, in a 1980 IEPA report inventorying and assessing surface impoundments in Illinois, no documented instances of groundwater pollution were attributed to the mining category (Piskin et al. 1980).

Aesthetic Degradation

Disturbed lands present safety risks in the form of highwalls or abandoned structures, but the aesthetic quality of these abandoned features is hard to measure. To some people, abandoned mines provide opportunities for mineral and fossil collection or other sources of recreation. To others, they represent danger and a deterioration of the panoramic view of the countryside. Some mined-out quarries have been reclaimed as recreation sites; for example, the Fairmount Quarry in Vermillion County is used as a private park for company employees.

CURRENT STATUS AND THE ENVIRONMENTAL IMPLICATIONS

Mining noncoal minerals generates much waste each year, although the exact quantity is unknown. Furthermore, we can only estimate how many acres have been disturbed by mining (34,943 acres, according to IDMM), and thus how many acres are covered in waste (500 acres in 1991, as estimated by IDMM). In fact, most noncoal mining operations in Illinois are small, disturbing less than 10 acres of land each year. They fall outside most reclamation provisions of SMLCRA.

The State has been regulating aggregate mining since 1962 and currently enforces provisions of SMLCRA when applicable (IDMM 1989). Before 1962, no reclamation was required and many mine sites were simply abandoned. Subsequent regulations (SMLCRA, Illinois Environmental Protection Act, and Regulation 35 IL. Admin. Code Subtitle C & D) require some reclamation and monitoring of extraction and waste disposal sites.

No specific legislation gives comprehensive mining regulations to characterize the waste constituents or to monitor soil or surficial material. Specific mining regulations cover performance standards as well as monitoring and verification criteria for surface water and air quality. Regulations also specify standards for groundwater quality, but no mining regulation requires monitoring and verification of groundwater quality (IDMM 1991).

No published reports define waste type or potential environmental impacts specific to disposal of wastes generated from extraction and processing of noncoal minerals in Illinois. In a report submitted to the Interstate Mining Compact Commission in 1991, however, the IDMM summarized available information concerning the impact of the USEPA's proposed Strawman II on current noncoal mining regulations. The federally proposed Strawman II regulations address noncoal mineral extraction and mineral-processing waste management under Subtitle D of the Resource Conservation and Recovery Act.

The IDMM concluded, for the purpose of the proposed Strawman II noncoal mining regulations, that:

- extraction wastes in Illinois (overburden, waste rock) do not meet the definition of toxic mine waste,
- reclamation of overburden and waste rock are adequately regulated under SMLCRA,
- discharges are adequately regulated under the Illinois Environmental Protection Act and Regulation 35 IL Admin Code Subtitle C & D,
- the main environmental impact of the abandoned noncoal mining industry is nonpoint source sediment loss from overburden or mine spoil deposition,
- overburden in Illinois consists primarily of glacial deposits dominated by clay, silt, or sand and gravel weathered to varying degrees; only rarely is toxic overburden encountered (see also Nawrot et al. 1982),
- none of the mine waste, with the possible exception of fluorspar and lead/zinc mine waste, can be considered toxic or likely to produce toxic discharge,
- no information pertaining to the presence/absence of nonpoint sediment loss is available for fluorspar and past lead and zinc mining in Illinois,
- noncoal mining waste consists primarily of the fine material washed out of the minerals during processing—mostly clay minerals, calcite, calcium carbonate, dolomite, calcium-magnesium carbonate, or quartz (silica) because limestone, dolomite, and sand and gravel are the most common minerals recovered (see also USBM 1990).

Included in IDMM's 1991 report was a summary of estimated miles of polluted water, acres of mine dumps, acres of disturbed land, and numbers of hazardous structures for minerals extracted in Illinois. These estimates have not been field-verified. Minerals mined in Illinois fall into three categories: (1) construction/commercial materials, (2) metallic ore, and (3) industrial materials.

Construction/Commercial Materials

Construction/commercial materials include sand and gravel, limestone, and peat. The wastes or hazards associated with mining of these materials are listed below. The values are estimates by IDMM (1991).

Construction/commercial waste

Waste or hazard	No. of units
Polluted water	0 miles
Mine dumps	100 acres
Disturbed land	32,555 acres
Hazardous structures	Unknown

Sand and Gravel Sand and gravel operations may wash the extracted mineral to suit local conditions and product demand. The wastes produced from the washing process are generally fine soil particles and, except for the dust, pose little or no environmental risk. Sand and gravel extraction may degrade the land because a large pit generally remains after the mine is closed, although sometimes these pits are converted to other useful purposes such as recreational areas.

Sand and gravel is used primarily as coarse, base material for road building and as a constituent in production of portland cement and asphalt-based concrete. Identification of all historic sites of sand and gravel extraction is difficult as most pits and quarries were operated with portable equipment and supplied local needs. More than one-half of all the sand and gravel produced in Illinois comes from the northeastern counties (Cook, Du Page, Lake, Kane, McHenry, Will), which contain the most extensive, high quality sand and gravel deposits. They also have the greatest need for the product. These heavily populated counties have significant programs for building and rebuilding the infrastructure (Sherrill et al. 1991).

Limestone and Dolomite Crushed limestone and dolomite are used for construction aggregate, rip rap, ballast, cement manufacturing, agricultural lime, and the manufacturing of other lime products. Most limestone and dolomite operations crush the stone; some may also wash the extracted mineral according to local conditions and product demand. Again, the wastes are generally fine grained (dust) and composed of calcite and dolomite particles. These quarries do pose some risk to human safety where highwalls remain ungraded and unprotected from public access. The grading or backfilling of many limestone quarries is not considered practical because of excavation depths (often greater than 200 feet) and relatively thin overburden (less than 100 feet). Excessive land and material would be needed to fill in these pits. Fencing may be an appropriate alternative. Abandoned limestone quarries, where the pH is suitable, may be stocked with fish and used for recreation.

Peat Peat mines do not produce waste. Excavated areas typically fill with water to form a lake. In Illinois, peat is produced for use as a soil conditioner. Commercial peat deposits are between 2 and 5 feet thick and cover more than 5 acres. Most commercial peat is found in Whiteside, Lake, Kane, and Cook Counties (Sherrill et al. 1991).

Metallic Ores and Fluorspar

Metallic ores mined historically in Illinois include lead and zinc from northwestern Illinois. Lead and zinc concentrates are also byproducts of fluorspar mining in southern Illinois. The wastes or hazards associated with mining of metallic ores and fluorspar are listed below. The values are estimates by IDMM (1991).

Metallic ore waste

Waste or hazard	No. of units
Polluted water	Unknown (miles)
Mine dumps	100 acres
Disturbed land	850 acres
Hazardous structure	Unknown

Fluorspar Fluorspar has been mined on a much smaller scale than that of aggregates. Most fine materials are produced in association with the process of concentrating the fluorspar and accessory mineral products. No specific information is available as to the nature of the distribution of mineral constituents found in fluorspar mining waste. It is known, however, that barite ($BaSO_4$), galena (PbS), and sphalerite (ZnS) are processed out of the ore and sold. What remains of the byproducts (fine waste components) accumulates in unknown concentrations in slurry waste ponds. The ponds are currently regulated under the Illinois Environmental Protection Act and Regulations 35 IL. Admin. Code Subtitle C & D, which provide for the protection of surface water and require compliance with surface water quality standards under the National Pollutant Discharge Elimination System (NPDES). No water quality problems have been noted at these slurry pond sites (IDMM 1991); but further study is necessary to determine whether any constituents of this mining waste are potentially toxic.

Most of the older fluorspar producers employed a processing technique different from that used today. The old process resulted in no specific waste piles (IDMM 1991). According to the AMLRC, however, a few waste piles consisting mostly of calcite and limestone and traces of galena and sphalerite remain at some of the larger fluorspar mines. (A few such as the Hillside Mine at Rosiclare in Hardin County have tailings ponds.) Few waste piles remain because much of the coarse waste generated at the older mines was sold as construction aggregate. This coarse material is no longer generated.

Fluorspar and lead miners followed veins of ore wherever they were encountered. Ore was mined upwards almost to the surface in many places, where now, there are deep subsidence pits and unstable mine ceilings. Consequently, the greatest dangers to the public in the Fluorspar Mining Region in Hardin and Pope Counties are from open shafts, subsidence pits, and deteriorating tipple structures. Rosiclare in Hardin County has two mines with tipples inside the city limits (AMLRC, personal communication 1993) .

Lead and Zinc Abandoned lead and zinc operations in the Galena district of northwestern Illinois were surface pits and underground mines that produced numerous piles of waste. Although these sites are a potential source for environmental concern, the information available to characterize the risks is limited (IDMM 1991). All the mines in the zinc–lead mining district were closed and abandoned by 1975.

Mine openings, rather than waste disposal, present a greater threat to health and safety. Open shafts, adits, and deteriorated tipple structures associated with inactive lead and zinc mines constitute significant safety hazards. Most of the mines and prospect diggings were abandoned without reclamation or sealing of shafts and adits. Numerous prospect diggings (shallow shafts) and mine shafts (up to 150 feet deep) remain open. The AMLRC has suggested that the environmental risks from abandoned waste piles may be reduced by using the materials, whenever practical, as fill in the reclamation of noncoal mines.

Industrial Materials Clay, shale, silica sand, and other siliceous materials (microcrystalline silica or tripoli, ganister, and novaculite) are mined in Illinois. The wastes or hazards associated with the mining of industrial materials are listed below. The values are estimates by IDMM (1991).

Industrial material waste

Waste or hazard	No. of units
Polluted water	0 miles
Mine dumps	300 acres
Disturbed land	1,538 acres
Hazardous structure	Unknown

Clay/Shale Processing of mined clay depends on the purity and specified end-product. Two kinds of clay are mined in Illinois, common clay or shale and fuller's earth. Common clay/shale is used in the manufacture of bricks, pottery, stoneware, and drain tile (Sherrill et al. 1991). Clay dust from brick or stoneware manufacturing is disposed of in approved landfills. Fuller's earth is used for its absorbing, decolorizing, and purifying properties (Sherrill et al. 1991). Fuller's earth is generally crushed, dried, and screened. The undersized waste particles have a variety of uses, such as bulk in animal feed, which leaves little processing waste to dispose of. What waste is left is nontoxic, so plants will grow on it.

Silica Sand Silica sand operations wash the extracted mineral. The resulting clay and very fine silica waste is impounded on site. In Illinois, most silica sand is composed of 100% clean quartz grains from the St. Peter Sandstone and requires little cleaning. This high quality sand is used in glass manufacturing, molding sand, hydraulic fracturing of oil-bearing reservoir rocks, and many industrial processes. The ISGS has reviewed the potential for recovering the clay mineral kaolin from the fine wastes. If implemented, such a scheme could further reduce the quantity of waste material generated.

Microcrystalline Silica, Ganister, and Novaculite Microcrystalline silica (tripoli), ganister, and novaculite, mined in southern Illinois, are composed largely of silica (SiO_2). Extraction of these materials produces little processing waste (IDMM 1991). Tripoli is used for abrasives and paint fillers. Ganister is a loosely consolidated siliceous material once used in making refractories. Novaculite gravel has been used for secondary roads, street paving blocks, and railroad ballast (Sherrill et al. 1991). It is now used for skid-resistant surfaces on blacktop roads.

Abandoned microcrystalline silica mines in Alexander and Union Counties have left unsealed and unreclaimed room and pillar mines. Several dangerous highwalls resulted when these mines caved in (AMLRC, personal communication 1993).

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Oil and Gas Exploration and Production

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Oil and gas have been produced in Illinois since the late 1800s. Along with the economic benefits of this production inevitably comes the generation of waste. How this waste is managed can have a significant impact on the environment (Collins 1971). A wealth of general information is available about the petroleum industry and its waste production and disposal. Not well documented, however, are the specifics on the amount and type of waste, waste management practices, and risks to the environment from oil and gas extraction in Illinois. The following discussion has been compiled from federal waste management reports, petroleum industry texts, and information available through the American Petroleum Institute (API), the Illinois Environmental Protection Agency (IEPA), and the Illinois Department of Energy and Natural Resource (ENR). Other reports, documents, and personal communications were provided by the Illinois Department of Mines and Minerals (IDMM) and the Illinois State Geological Survey (ISGS).

Management of wastes and byproducts (not all are wastes) from oil and gas recovery is controlled by environmental regulations. Responsibility and liability for protection of human health and the environment from harmful waste management practices and discharges are the goals of these regulations: (1) Resource Conservation and Recovery Act (RCRA), (2) Safe Drinking Water Act (SDWA), (3) Clean Water Act (CWA), (4) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), (5) Clean Air Act (CAA), and (6) other state-specific regulations (API 1989). In Illinois, oil and gas exploration and production are regulated by the IDMM under IL ADMIN CODE 62, Part 240: The Illinois Oil and Gas Act.

In the past, oil and gas exploration and extraction have locally damaged soil, water resources, and wildlife in Illinois. The damage has been documented by the IEPA, IDMM, Illinois Natural History Survey (INHS), Illinois Department of Conservation, and many other organizations mandated to monitor various aspects of the environment. Several sites have been remediated by the industry. Practices that led to environmental damage in the past have theoretically been eliminated by the environmental regulations listed above as well as new State regulations on the oil and gas industry, and by the ability of the IDMM to levy Notices of Violation (NOV) when violations are discovered. Industry and government are working together to protect the soil, surface water, and groundwater from improper disposal of solid and liquid wastes related to exploration and production.

WASTE GENERATION AND MANAGEMENT

Hydrocarbons (oil and gas) are extracted from the earth's subsurface. Exploratory wells drilled to search for oil and gas usually result in dry holes that are plugged and abandoned. When an oil or gas reservoir is discovered, however, development wells are drilled to extract (or produce) the oil and/or gas. Wastes are generated by drilling operations, well completions and well workovers, gas plants, and other field production facilities (API 1989). These activities generate three basic types of wastes: (1) produced water, (2) drilling fluids, and (3) associated waste products. Little waste is generated at gas wells; most waste is generated at oil wells (API 1989, OTA 1992).

Produced water that accompanies the oil or gas extracted from the subsurface accounts for more than 90% of all oil and gas waste. Water occurs naturally in the reservoir, but may be combined with supplemental water pumped into the reservoir in secondary recovery operations. Of the three basic types of waste generated by the location and production of hydrocarbons in Illinois, the best documented is produced water, including (1) fresh or saline water (brine); (2) naturally derived constituents such as petroleum hydrocarbons, radionuclides, or naturally occurring metals; and (3) any chemical compounds added for treatment such as coagulants, corrosion inhibitors, and paraffin control agents (API 1989, OTA 1992). Produced fresh water poses little environmental risk; but brine, if improperly or illegally disposed of, poses a greater risk to the disposal environment.

Porous, permeable sandstones and limestones form "reservoirs" that hold gas, oil, and brine deep below ground surface (fig. 9.3). Impermeable rock overlying the reservoir traps the water along with the hydrocarbons. Because gas has the lowest density, it can be found in the pores near the top of the trap or in solution with the oil. Unless in solution, the oil sits just under the gas and on top of the typically denser, saline water (brine), which occurs below both the oil and gas. Because oil, gas and brine are closely associated, all three are commonly produced together.

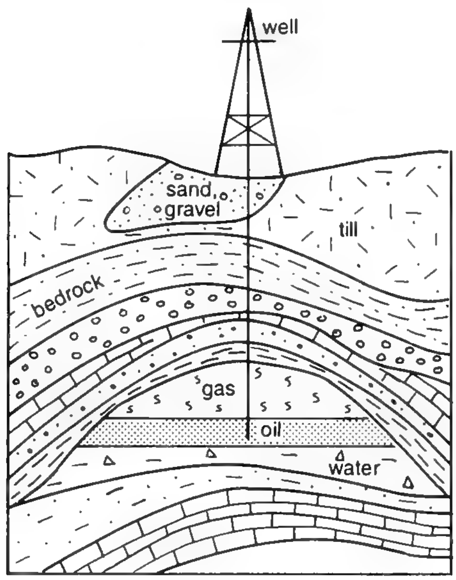

Figure 9.3. Water-oil-gas relationship at a typical well site. The gas and fluids migrate to the highest point of the structure and sort themselves out according to density. As the reservoir becomes depleted, the close proximity of the hydrocarbons to the brine allows recovery of all three components.

Produced water must be separated from the oil or gas before these products can be piped or sold. Figure 9.4 shows how oil, gas, and water are separated and wastes are generated in a typical production operation. In Illinois, most natural gas produced with oil (casinghead gas) is flared to the atmosphere, as stipulated by law; little is actually collected and sold. Because it is a minor constituent in Illinois' comparatively shallow reservoirs, it is neither economically feasible nor practical to collect the gas and compress it to the pressures required to enter the commercial, natural gas pipeline network.

The quantity of water produced depends upon the recovery method as well as the nature of the rock formation, initial fluid saturation values, and the length of time the oil field has been producing. The three basic types of oil recovery are called primary, secondary, and tertiary. Of the three, primary recovery commonly produces the greatest ratio of oil to water. As oil and gas are removed from a reservoir, pore spaces formerly occupied by the hydrocarbons may be filled with another fluid, usually brine, which is also available in the formation. A well may produce mostly oil at first; but as the reservoir is depleted, the ratio of produced water to oil increases (API 1989).

In secondary recovery (waterflooding), produced brines are reinjected into the reservoir to maintain (or restore) the pressure in the reservoir and force the hydrocarbons to migrate away from the injection site toward a nearby production well. Tertiary recovery uses polymers, microbes, CO_2, and surfactants to sweep or flush oil from the reservoir and increase the total amount of oil recovered. If the price of oil increases, tertiary recovery may become common in Illinois.

There are no annual records of how much waste is generated, but estimates of produced water have been made periodically. An ISGS study (Bell 1957) reported that 181 million barrels of produced water were recovered for 82 million barrels of oil produced, a ratio of 2.2:1. In 1978, the IEPA estimated that 973,000 barrels of brine were disposed of daily in Illinois. This translates to 355 million barrels of produced water for the 25 million barrels of oil produced that year, a ratio of 14:1. The 1981 average brine to oil ratio in Illinois was approximately 28:1 (Moe 1984). The most recent estimate was made in 1985 by the American Petroleum Institute and the U.S. Environmental Protection Agency (USEPA): for 30 million barrels of oil, 1.2 billion barrels of produced water was generated, a ratio of 40:1 (OTA 1992). Because the Illinois Basin is a mature basin where secondary recovery efforts are widespread, this trend toward increased generation of produced water will probably continue.

Produced waters have been disposed of using a variety of practices in Illinois, including open and unchecked dumping into rivers and streams, evaporation from holding ponds, and reinjection into porous, non-oil-bearing formations. In the 1930s, produced water from the first oil wells in the state was allowed to spill onto land surface and into rivers and streams. Disposal techniques changed in the 1940s from unchecked spillage to the use of unlined holding or evaporation ponds. Because the average precipitation rate exceeds the average evaporation rate (Roberts and Stall 1967) in Illinois, however, brines did not evaporate quickly enough to avoid infiltration through the unlined pond bottoms into local aquifers (IEPA 1978, Coleman and Crandall 1981, Reed et al. 1981, Hensel and McKenna 1989). IDMM (Sours et al. 1985) and IEPA (Piskin et al. 1980) have

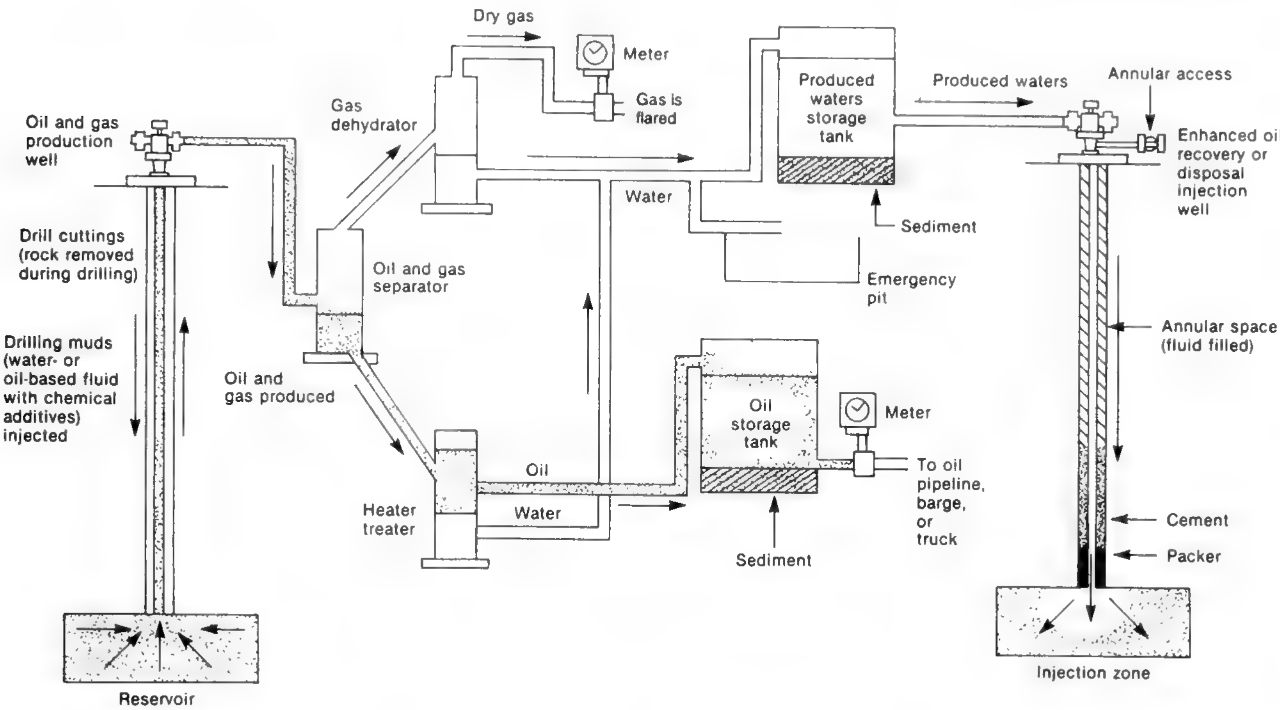

Figure 9.4. Separation of oil, gas and water. Separation generally occurs at the well site. Produced water is trucked to an injection well, or temporarily stored in an impoundment, waiting for trucking or injection; or reinjected at the site, as shown in this illustration. During this process other wastes are produced. The gas is generally burned off. Tank bottoms, or sediment, accumulates in the bottom of the storage tanks. This by-product is reinjected or stored in holding tanks. Drilling muds and drill cuttings are impounded and buried or spread out over an adjoining field. (Based on USEPA Report to Congress: Management of Wastes for the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy. 1987)

estimated that more than 8,600 brine holding ponds were in use in Illinois at one time. In 1980, the IDMM issued a directive recommending the closure of these holding ponds. The IDMM estimates that approximately 500 to 700 pits remain in the state today (L. Bengal, IDMM, personal communication 1993). Proposed regulations (Illinois Admin. Code 62, Ch. 1, Sec. 24, Subpart H) will prohibit evaporation pits. All existing pits must be closed within 6 months of the adoption of these rules. The alternative is injection technology, which is commonly used today. With its improvements in the 1950s, reinjection of brine to the subsurface began both for disposal and for secondary recovery.

Drilling fluids include drilling muds and drill cuttings (rock removed by drilling) and account for 2% to 4% of all oil and gas waste (OTA 1992). Drilling muds are used to clean the drill cuttings from the bottom of the hole and to transport them to the surface, lubricate the rotating bit and drill string, control formation pressure to prevent blowouts, and stabilize the borehole wall to prevent caving (LeRoy et al. 1977). Composition of these drilling fluids can be complex and varied, depending on the characteristics of the formation (API 1989, OTA 1992). There are two categories of drilling muds: water-based muds (used for most types of drilling) and oil-based muds (used for water-sensitive formations). These muds contain four essential parts: (1) liquids (fresh water, saline water, oil, others), (2) viscosity-building active solids (in Illinois, most often bentonite clays), (3) density-building inert solids (often barite), and (4) other additives such as polymers, starches, and other chemicals, which are rarely used in Illinois (API 1987, API 1989).

The amount of drilling mud produced depends upon the nature of the formation being drilled and the depth of the well. Drilling fluid can be deposited on-site in reserve pits (surface impoundments), or it can be deposited on another site or into surface water. The method of disposal depends upon the circumstances at the site and state regulations (API 1987, API 1989, OTA 1992). In Illinois, drilling fluids are commonly disposed of through land spreading because of the benign nature of the fluid (water less than 1000 ppm Cl and bentonite). In 1985, the American Petroleum Institute and the USEPA estimated that 2.6 million barrels of drilling waste were generated (OTA 1992). No data are available for Illinois, however, documentation of the generation and disposal of these fluids is not required.

Other associated waste products represent a relatively small percentage (<1%) of the overall wastes generated. These wastes are generated by drilling, well completion and workover operations, gas plants, and field production facilities. The list of waste products produced by these activities includes hydraulic fluid, weighting agents, acids, rigwash (detergents and solvents), sediment, water, tank bottoms, oily debris (used oil, filters), produced sands, and paraffin (API 1987, API 1989, OTA 1992). Depending on quantities and their chemical or physical characteristics, these spent fluids, slurries, sludges, and solids may be stored, treated, landfilled, and injected into Class II disposal wells; discharged under National Pollutant Discharge Elimination System (NPDES) permits; or recycled. It is unclear how much of this waste is generated in Illinois or what methods of disposal have been and are being used.

THE ENVIRONMENTAL RISKS OF WASTE DISPOSAL

Mismanagement of the large volumes of produced water presents a greater risk to the natural environment and human welfare than does the disposal of other wastes generated by the oil and gas industry (IEPA 1978, Coleman and Crandall 1981, Hensel and McKenna 1989, Hall 1990). Most documented cases (ENR and IEPA studies at state level and USEPA nationwide studies) of damage due to the disposal of exploration and production waste either resulted from violating State and Federal requirements or occurred before the regulations were in place. If proper oil drilling and waste disposal practices are used, no environmental damage is likely to occur because these practices are engineered and regulated to protect soil, wildlife, and usable sources of drinking water (IEPA 1978, Coleman and Crandall 1981, EPA 1987, Hensel and McKenna 1989, GAO 1989, Hall 1990, OTA 1992, IDMM 1993).

Improper disposal of produced water (brine) has the potential to severely impact agricultural lands, crops, forest, streams, aquatic life, surface water, and groundwater. Potential contamination paths for oil field brines are illustrated in figure 9.5. The following discussion focuses on potential paths related to reinjection and disposal, including old impoundments and injection wells. Regulations are designed to prevent contamination through these routes by setting wellhead performance standards, monitoring impoundment designs, and conducting site inspections.

Runoff and leachate infiltration from treatment and disposal facilities, reserve pits, and unlined disposal pits can degrade soil and groundwater, and harm wildlife. Disposal of produced water into unlined holding ponds was common before 1980. Field studies have shown that environmental damage from infiltration of brine into surface and groundwater is detectable at closed and covered impoundment sites, especially when the pits were filled without first removing their contents (Sours et al. 1985, Hensel and McKenna 1989). Effects of the past practice of brine disposal into unlined or improperly managed surface impoundments have been documented by the IEPA (IEPA 1978, Piskin et al. 1980, Coleman and Crandall 1981), the ISGS (Reed et al. 1981, Hensel and McKenna 1989), ENR (Sours et al. 1985), and INHS (Smith 1971).

Escape brines, fracturing fluids, produced waters, and hydrocarbons from improperly functioning injection or disposal wells, or from abandoned injection or disposal wells left unplugged or improperly plugged, can degrade groundwater, agricultural land, and domestic and irrigation water sources.

When brine or these other potential pollutants come in contact with potable (drinking) water resources, the water is rendered unusable. Upward migration of brine, although difficult to detect, has the potential to cause damage. Groundwater contaminated by brine will remain contaminated much longer (residence time) than surface water contaminated by brine because dilution is less likely to occur in subsurface water than in surface water bodies. Also, natural filtering processes are relatively slow.

The USEPA has determined that produced water injected for the purpose of secondary recovery is not a waste subject to regulation. It is, in fact, beneficially recycled (API 1989). In practice, all produced water eventually must be disposed of. Any risks associated with subsurface injection are the same whether the produced water is used for enhanced recovery (waterflooding) or is simply disposed of by reinjection. In the field, it is difficult to distinguish between the two operations (Bell 1957, IEPA 1978).

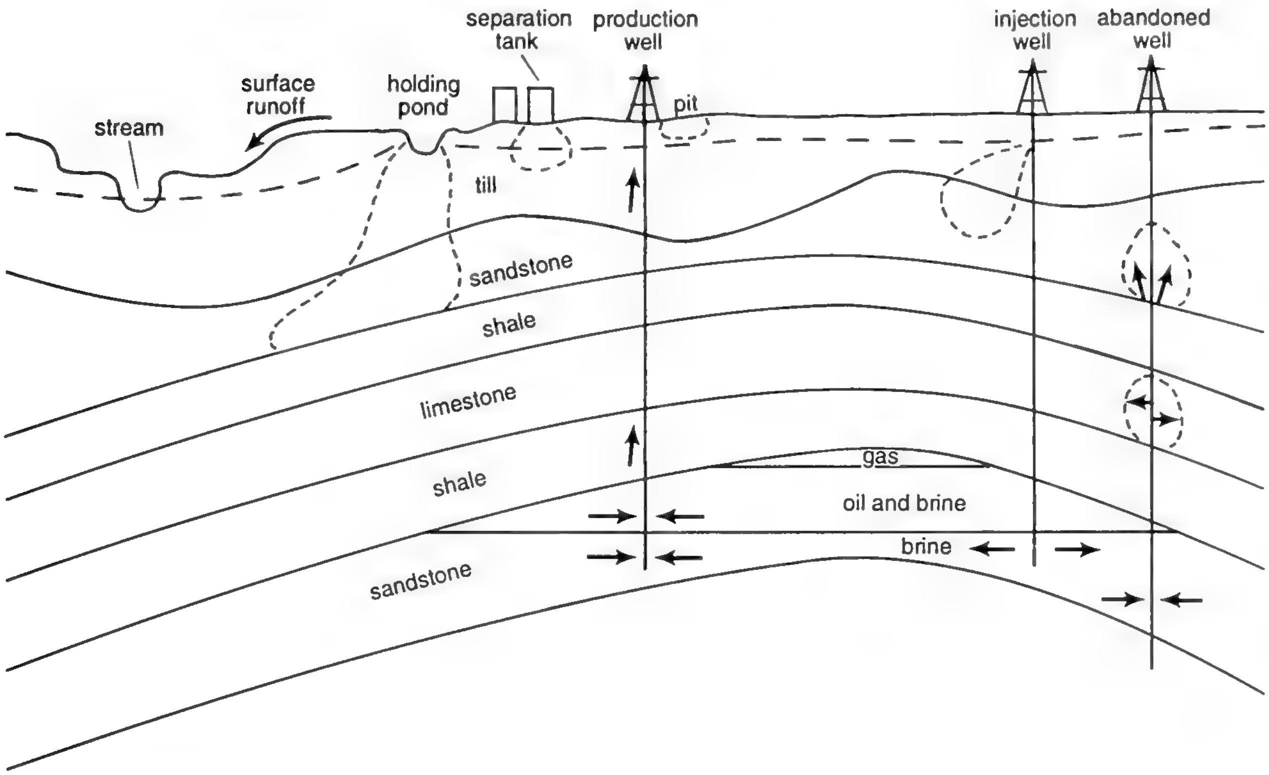

Figure 9.5. Potential routes for improperly disposed oil and gas production and exploration wastes to contaminate the environment (After Hensel & McKenna, 1989). Current regulations should prevent contamination from these sources.

Injected disposal of brine water is accomplished in much the same manner as secondary recovery: it is reinjected into subsurface formations through wells converted or specially drilled for this purpose. The difference lies in the final destination of the injected fluids; potential routes for contamination of the environment are the same for both injection practices as illustrated in figure 9.5.

In Illinois, the most conspicuous and significant consequence from improperly disposed produced water may be damage to surficial soils. In a recent ISGS study (Hensel and McKenna 1989), hundreds of acres of land in Clay County were documented as damaged or unusable for agriculture because of past spills and leakage from holding ponds. Soil erosion can increase because vegetation is killed and the soil becomes disaggregrated and highly impermeable (Sours et al. 1985). Runoff from these unvegetated or sparsely vegetated brine-damaged lands concentrates dissolved minerals in surface waters.

Disposal of most drilling fluids in Illinois poses little risk due to the benign character of the fluids. Spreading this waste over the land costs little and apparently does not adversely impact the soil. Land application may not be appropriate for all drilling muds, however, as some may contain substantial quantities of oil and various additives (OTA 1992).

Associated wastes such as completion fluids and general oil field waste, if properly managed, should not pose risks to the environment. Oil well completion fluids are stored in temporary pits or tanks and the waste is eventually disposed in a Class II injection well. The temporary pits must be emptied and covered within 6 months after completion of the well. General oil field waste must be hauled away at the conclusion of any activity that produces it.

CURRENT STATUS AND THE ENVIRONMENTAL IMPLICATIONS

Regulations

The RCRA was amended in 1980 to reflect Congressional opinion that wastes generated by oil and gas exploration and production required special consideration. The USEPA was directed to study oil and gas wastes and determine their status. Consequently, most oil and gas production wastes are exempt from regulation under the RCRA hazardous waste provisions Subtitle C (USEPA 1988 regulatory determination) (OTA 1992). Examples of exempt wastes are produced water; drilling fluids; drill cuttings; rigwash; well completion, treatment, and stimulation fluids; basic sediment, water and other tank bottoms from storage facilities that hold crude oil; hydrocarbon-bearing soil; waste crude oil from primary field operations and production; wastes from subsurface gas storage and retrieval; and constituents removed from produced water before injection or disposal (EPA 1987, API 1989, OTA 1992).

Oil and gas exploration and production wastes are regulated primarily at the state level; the US EPA has not developed a regulatory program under Subtitle D for these wastes. However, the Agency does regulate underground injection of produced waters under the Safe Drinking Water Act, surface discharges of oil and gas wastes under the Clean Water Act, and air emissions under the Clean Air Act. The IEPA and IDMM have primacy in implementing these federal regulations. The Bureau of Land Management has authority to regulate exploration and production wastes on federal lands.

A Congressionally mandated study by the USEPA (1987) recognized that existing state and federal regulations are generally adequate. The report stated, however, that certain regulatory gaps did exist and enforcement issues relating to the management of oil and gas wastes became of concern to the federal government. Consequently, the Illinois Department of Mines and Minerals reorganized its Oil and Gas Division and computerized its well records to better regulate oil and gas activities (IDMM 1988, 1989, 1990). The reorganization resulted in the creation of an Administrative Unit, a Permit Unit and a Compliance Unit within the Oil and Gas Division. The Compliance Unit was given enforcement procedures that established hearing procedures and authorized the assessment of civil penalties.

IDMM field inspectors are now able to issue Notices of Violation for wells not in compliance with state and federal regulations. Notices of Violation have been issued for the following infractions: operating an injection well without a permit; operating an injection well without tubing and packer; other operating violations at wells; general lease violations, including contamination dike (firewall) maintenance; and violations concerning equipment leaks and illegal brine disposal (IDMM 1990).

The IDMM is concluding a comprehensive rewrite of the oil and gas rules that address oil and gas activities, including waste disposal regulations. Final regulations were expected by the fall of 1993 (L. Bengal, IDMM, personal communication 1993). New regulations (IL Admin Code Title 62, Part 240: Illinois Oil and Gas Act) were adopted in February 1993 resulting from this effort (IDMM 1993). Although no comprehensive field study of Illinois oil and gas waste disposal activities has been published, these regulations reflect the expected future status of oil and gas waste and suggest their environmental implications.

The regulations provide for the disposal of drilling, completion, and plugging wastes and the restoration of on-site pits. Drilling fluid waste and drill cuttings are to be stored temporarily in completion pits or above ground in a portable container; disposal may be either on-site burial or surface application (spread on an adjoining field). Completion fluid waste must be collected at the well site in a lined completion pit for temporary storage or in a leak free, aboveground container. All fluids must be removed from the pit and injected into a Class II well, or held in aboveground tanks or containers ready for disposal. Completion and drilling fluid circulation pits must be filled and leveled within 6 months of completion, and the area must be reclaimed to avoid subsidence or leakage of fluids. Where applicable, the disposal area must be compacted well enough to support farm machinery or to recover its original condition. Within 6 months after a well is plugged, the free liquid fraction of the plugging fluid waste, consisting of produced water and crude oil, must also be removed from the pit and disposed of in a Class II injection well or stored above ground in tanks ready for disposal. The remaining plugging fluid wastes may be buried on site.

All general oil field wastes (paper, trash, oily rags, chemical containers, oil filters and gaskets, used motor oil, hydraulic fluids, diesel fluids, and similar wastes generated during completion, production, and plugging) must be temporarily stored in on-site containers and removed from the site before or at the conclusion of the given activity. These wastes may not be buried on-site, deposited in drilling or completion pits, or mixed with drilling fluid or completion fluid wastes before disposal.

Surface pollution can be avoided by proper disposal of produced water and other liquid wastes. Underground injection is an acceptable method, provided the proper permit is obtained from the IDMM and IEPA. The IDMM is proposing regulations that will prohibit evaporation pits unless the pits have poured concrete walls. Evaporation pits lined with fiberglass or plastics will no longer be allowed, and existing pits that do not meet the standards of the new regulations must be filled.

Produced water is generally disposed at the well site or hauled or piped to a nearby injection well. If the brine cannot be reinjected into nearby wells, the brine or produced water is hauled by permitted haulers to approved disposal sites. A written record of how much brine has been removed from the well site is provided to the Division of Oil and Gas (IDMM 1993).

Injection of produced water must take place below all formations containing usable sources of drinking water. The mechanical integrity of the injection wells must be tested every 5 years at a minimum and, as part of the permitting process, evidence must be provided that all water wells within 1/4 mile of the injection well have been properly constructed and/or plugged to avoid potential migration of injected fluids.

Environmental Damage and Management

The degree of environmental damage caused by past disposal of oil exploration and production wastes is incompletely documented statewide. In 1980, the IEPA conducted a telephone survey of persons representing Soil Conservation Districts, Soil Conservation Service offices, Cooperative Agricultural Extension Service offices, and Regional Planning Commissions. Each contact was asked to estimate the areal extent of land damaged by brine in each county. It was estimated that between 28,200 and 38,236 acres have been damaged to the extent that 50% or more of the vegetation had been destroyed (Coleman and Crandall 1981). This information was never field-verified; and after studying selected aerial photographs, the IEPA concluded that the estimate was low.

In 1985, ENR conducted a questionnaire and telephone survey to determine which oil-producing counties had performed a study to assess the extent of oil field brine damage. Forty-three counties reported that they had not performed an assessment and three counties reported that an assessment was performed for them. The questionnaires and telephone inquiries were directed to the County Soil and Water Conservation Districts (SWCD). This study also estimated damage to more than 38,000 acres. Contaminated water wells, erosion, and damage to surface water quality in streams were also reported (Sours et al. 1985).

The few field studies that have been done in Illinois (IEPA 1978, Sours et al. 1988, Hensel and McKenna 1989) suggest that the types of damage associated with exploration and production wastes found in these study areas could be expected in other oil-producing regions of the state, particularly the major producing counties (fig. 9.6). These studies found impacts on surface water bodies, groundwater, and surficial soils. The first step toward management of environmental damage is documentation. The degree of damage caused by past disposal of exploration and production wastes is dependent on the disposal practices used in the area, the intensity of oil development, and the local and regional geology.

Pollution prevention and waste reduction are the best forms of waste management. It is advisable to reduce the volume and noxiousness of all wastes, and to increase the recycling of produced water, drilling fluids, and associated oil and gas wastes. The economic incentive to reduce and recycle is strong because proper management of these wastes is expensive. Currently federal and state regulations require that the responsible parties clean up problem areas associated with improper management practices. Reducing the amount of material managed will decrease potential liability. The major oil companies are also studying reduction as a means of decreasing the direct cost of waste management. Success in reduction and recycling as waste management practices will depend on industry support and good tracking of the waste streams and chemical additives (OTA 1992).

Overall Trends

Oil production is on the decline in Illinois, so waste production associated with new drilling and well completion is also on the decline. Waste production

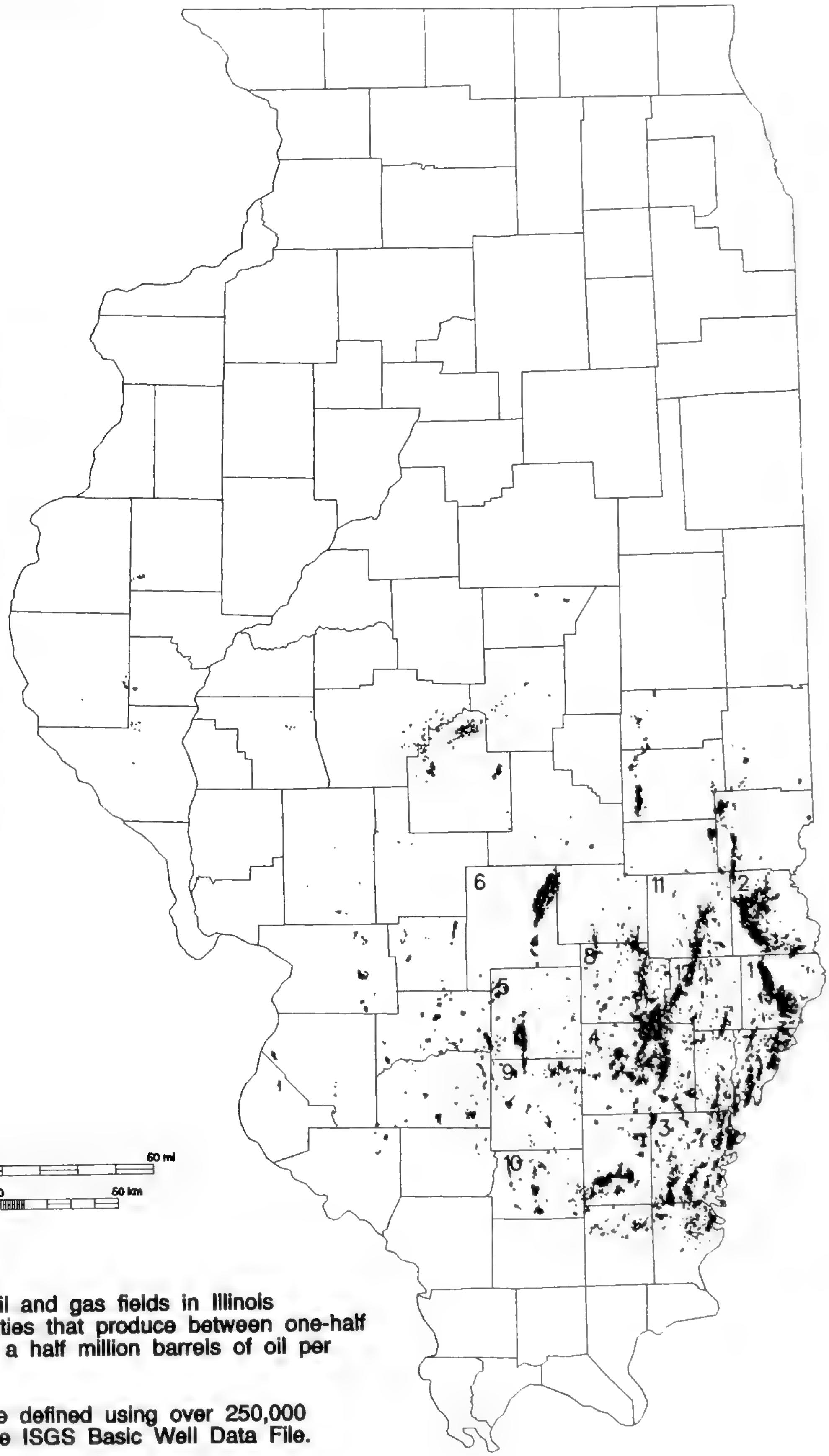

Figure 9.6
Location of oil and gas fields in Illinois and the counties that produce between one-half and two and a half million barrels of oil per year.

The fields are defined using over 250,000 wells from the ISGS Basic Well Data File.

associated with pumping oil from older wells is, however, on the rise because the ratio of produced water to oil is increasing as reservoirs become depleted. As more wells are plugged and abandoned, the quantity of waste associated with plugging an oil or gas well increases.

In Illinois, the trend is toward underground injection of exploration and production waste and away from disposal into surface impoundments.

Generation and management of oil and gas wastes will face increased scrutiny and regulation in the future.

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TOXIC RELEASE INVENTORY

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The chemical industry has grown dramatically since World War II. More than 70,000 chemicals are available commercially and over 1,000 new chemicals are proposed for manufacture annually. Synthetic organic chemicals are used in the production of foods, medicines, consumer goods and building products. Not all chemicals used as raw materials become part of the product, however. Billions of pounds of chemicals are released into the environment as wastes. Little is known about the ultimate impact of many of these chemicals on human health and the environment.

A first step toward developing a national study of movement of toxic chemicals in the environment, was the enaction of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) which was included in the Superfund Amendments and Reauthorization Act (SARA). This act established programs to provide information to the public about hazardous chemicals on a community level including creation of the Toxic Release Inventory (TRI). The TRI is the first national database of information about toxic chemical releases and transfers by manufacturing facilities. The information compiled via EPCRA's programs is useful to community emergency planners responsible for protecting the public in the event of chemical release.

TRI, created by section 313 of EPCRA, requires certain companies to file annual reports disclosing both routine and non-routine releases of listed toxic chemicals to the environment. The 1991 reporting requirements listed over 300 toxic chemicals and 20 categories of chemical compounds. Air, water and land releases of these chemicals as well as transfers to off-site treatment, storage and disposal facilities must be reported to the USEPA and state government. Appendix 10.1 contains a list of TRI chemicals. TRI includes releases occurring as a result of normal business operations and non-routine releases. The TRI does not report violations of environmental laws on the part of manufacturing facilities. In Illinois, the IEPA is charged with the administration of section 313 of EPCRA.

Facilities subject to reporting under section 313 are identified based on the type of industry, number of employees and threshold levels of toxic chemicals used or produced. Facilities required to report are those with 10 or more full-time employees and primary SIC codes 20 - 39. A description of these SIC categories is found in Table 10.1. This selection of facilities includes most traditional manufacturing facilities but excludes utility companies, publicly owned treatment works and waste treatment, storage and disposal facilities. Facilities which manufacture, process or otherwise use a listed toxic chemical or chemical category are required to report. As of 1989, facilities that manufacture or process toxic chemicals in excess of 25,000 pounds per year must meet the reporting requirements, as must facilities that use in excess of 10,000 pounds per year (includes all other uses). The threshold value for manufacturing or processing was sequentially lowered from the level of 75,000 pounds in the 1987 reporting year to 50,000 pounds in 1988 and finally to 25,000 pounds in 1989.

The industrial processes which manufacture, process or use TRI chemicals vary widely. A range of toxicity also exists among TRI chemicals. Small reported releases for some chemicals may be of more concern than larger releases of others. Chemicals included in TRI may be delisted if it is determined by USEPA that they pose a minimal threat to human health and the environment. In several cases, chemicals have been delisted, and resulted in dramatic reductions in reported releases by specific facilities or industry groups. Those chemicals that have been delisted or added, thus affecting TRI reporting for 1991, are listed in Table 10.2.

Delistings and a change of threshold quantity for manufacturing and processing, make TRI information difficult to compare year to year. Excluding delisted chemicals from an analysis can make data from prior years comparable to data from subsequent years (USEPA, 1991). It is more difficult to adjust for the change in threshold values that took place for reporting year 1989.

Several limitations of the TRI database should be noted. First, TRI reporting does not include every chemical released to the environment; it is limited to only those specifically listed toxic chemicals or categories. Secondly, not every facility is required to report. TRI reporting is limited to certain SIC

Table 10.1. Description of SIC Codes 20-39

Code	Description
20	Food and Kindred Products
21	Tobacco Products
22	Textile Mill Products
23	Apparel and Other Textile Products
24	Lumber and Wood Products
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing and Publishing
28	Chemicals and Allied Products
29	Petroleum and Coal Products
30	Rubber and Miscellaneous Plastics Products
31	Leather and Leather Products
32	Stone, Clay and Glass Products
33	Primary Metal Industries
34	Fabricated Metal Products
35	Industrial Machinery and Equipment
36	Electronic and Other Electrical Equipment
37	Transportation Equipment
38	Instruments and Related Products
39	Miscellaneous Manufacturing Industries

Source: Standard Industrial Classification Manual 1987.

categories and only for those facilities with 10 or more employees. Small facilities may exist which release large amounts of toxic chemicals to the environment. In addition, the number of different industries processing and using toxic chemicals may become more diverse as chemical use expands. The threshold levels established for TRI reporting may exempt a large number of facilities that use or process TRI chemicals but not to threshold level. As a result, the number of facilities required to meet TRI reporting requirements is smaller than the industrial universe. The third limitation of the TRI database cited most frequently is the quality of the data estimated and reported by facilities. TRI requires facilities to report data as accurately as possible. Release data may be estimated in a number of ways. Much of the TRI data have been estimated with an unknown level of accuracy. In addition, changes

Table 10.2. Delistings and Additions of TRI Chemicals Affecting Reporting 1987-1991

Delistings
Aluminum Oxide (Non-Fibrous Forms)
C.I. Acid Blue #9, Diammonium Salt
C.I. Acid Blue #9, Disodium Salt
C.I. Pigment Green 7
C.I. Pigment Blue 15
C.I. Pigment Green 36
Melamine Crystal
Sodium Hydroxide (Solution)
Sodium Sulfate (Solution)
Terephthalic Acid
Titanium Dioxide
Additions
Bromotrifluoromethane (Halon 1301)
Trichlorofluoromethane (CFC-11)
Dichlorodifluoromethane (CFC-12)
Dichlorotetrafluoroethane (CFC-114)
Monochloropentafluoroethane (CFC-115)
Dibromotetrafluoroethane (Halon 2402)
Bromochlorodifluoromethane (Halon 1211)
Allyl Alcohol
m-Dinitrobenzene
Dinitrotoluene (Mixed Isomers)
Creosote
p-Dinitrobenzene
Isosafreole
2,3-Dichloropropene
o-Dinitrobenzene
Toulene Diisocyanate (Mixed Isomers)

Source: **Toxics in the Community - National and Local Perspectives: The 1989 Toxics Release Inventory National Report**; US EPA; EPA 560/4-91-014; September 1991.

Fifth Annual Toxic Chemical Report, Illinois EPA; IEPA/ENV/93-005; April 1993.

made to reporting requirements, especially the non-requirement of reporting of chemicals transferred off-site for recycling in the 1987 through 1990 reporting years, have been criticized as producing "paper reductions and increases" rather than actual ones. In 1991, reporting requirements changed again to include transfers off-site for recycling or energy recovery. This change resulted in a "paper" increase in release levels for the 1991 reporting year. Many facilities have admitted that some of their releases have decreased due to better measurements. Despite these limitations, USEPA believes that the accuracy and completeness of TRI improves every year that the inventory is compiled.

Users of TRI data have been frustrated that the reasons for reductions and increases have not been part of TRI reporting. Prior to 1991, source reduction information was voluntary and the information submitted was often incomplete. Source reduction, recycle and energy recovery information was required beginning in 1991 and includes more detailed information. Critics claim that there are many possible causes for reductions and increases in TRI chemicals that have little to do with source reduction and pollution prevention activities. USEPA and the Research Triangle Institute (RTI) conducted a survey of reporting facilities to quantify the impact source reduction has had on changes in TRI data. The study compared 1989 with 1990 TRI data and estimated the extent to which source reduction and other factors accounted for decreases in TRI reporting.

The study considered source reduction, production fluctuations and changes in measuring techniques as possible causes for changing levels of chemical release (Craig, 1993). The researchers were able to attribute 52% of the net decrease between 1989 and 1990 to three factors: 45% to source reduction, 5% to changes in production levels and 2% to changes in estimation techniques. Unfortunately there is no universal agreement on a definition of source reduction. For example, many companies consider on-site recycling to be source reduction, leading to confusion about how many companies are involved with true pollution prevention activities. Although TRI data have the potential for measuring pollution prevention progress, the USEPA-RTI study indicates that certain factors may mask the actual cause and effect relationship leading to decreased (or increased) releases. Despite its limitations, the USEPA-RTI study provides useful insights for future analysis.

The Pollution Prevention Act of 1990 resulted in the expansion of TRI reporting requirements. Beginning in the 1991 reporting year, TRI facilities were required to submit information about source reduction, recycling and energy recovery for each TRI chemical. As USEPA expands its role in encouraging industrial source reduction and recycling, TRI will become a more important tool to gauge pollution prevention efforts on the federal, state and facility level.

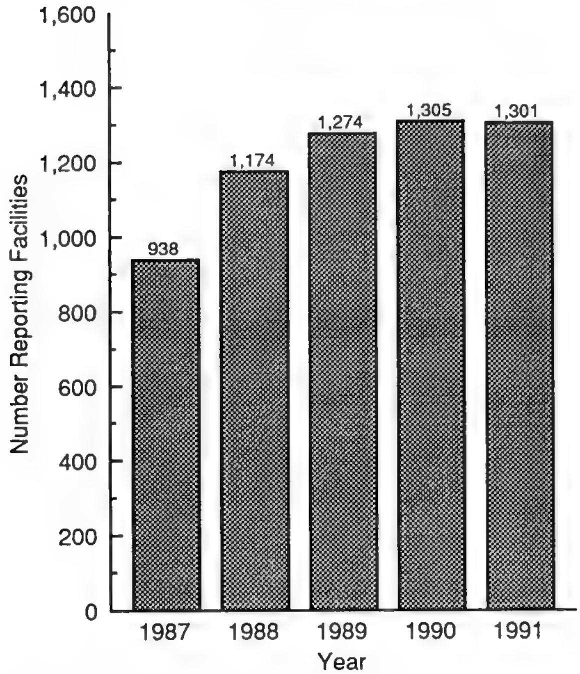
ILLINOIS TRI TRENDS

Five years of TRI data for Illinois were available for this discussion (1987, 1988, 1989, 1990, 1991). For each of these years, IEPA has published a Toxic Chemical Report, summarizing data submitted by facilities. The 1991 report was included in only the general discussions due to its date of publication. Using these reports, overall trends in TRI for the state can be identified.

The number of facilities submitting TRI report forms in Illinois has increased. The number grew from 938 facilities in 1987 to 1301 facilities in 1991 or an increase of about 39% (see Figure 10.1). The largest part of this increase occurred between 1987 and 1988 with a 25% increase. There are a number of possible explanations for this increase. As more facilities learn about the TRI reporting requirements, one would expect an increase in the number of reports submitted. The lowering of threshold levels that occurred in 1988 and 1989 may also be responsible for the increase in the number of reporting facilities. Changes in the economy in Illinois may also affect TRI reporting. As new businesses are started in Illinois and others leave, the universe of TRI facilities will change.

While the number of facilities reporting under TRI requirements has increased since 1987, the total reported pounds of chemicals released have declined. Figure 10.2 shows the decrease of TRI releases in Illinois from 439.9 million pounds in 1987 to 232.6 millions pounds in 1990 and then to 311.3 million pounds in 1991. It seems that dramatic fluctuations have occurred since the implementation of Section 313 in 1987. As with any other kind of regulatory reporting, reported volumes will change as requirements change. A large portion of the decrease from 1987 through 1989 is due to the delisting of chemicals by USEPA. The increase seen in 1991 is explained by the addition of recycling and energy

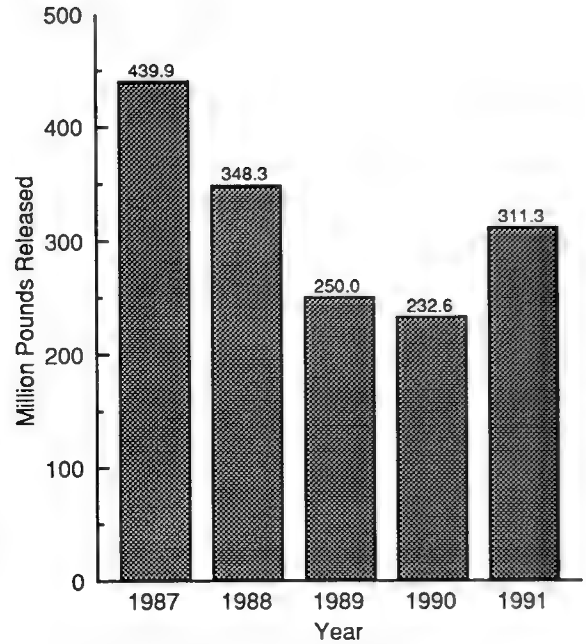
Number of Illinois TRI Facilities
1987-1991



Source: Illinois Toxic Chemical Reports 1987-1991

Figure 10.1

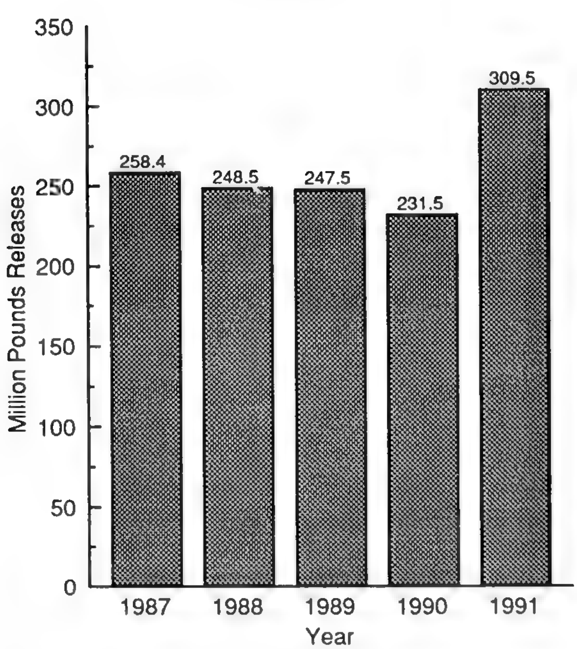
Total Illinois TRI Releases
1987-1991



Source: Illinois Toxic Chemical Reports 1987-1991

Figure 10.2

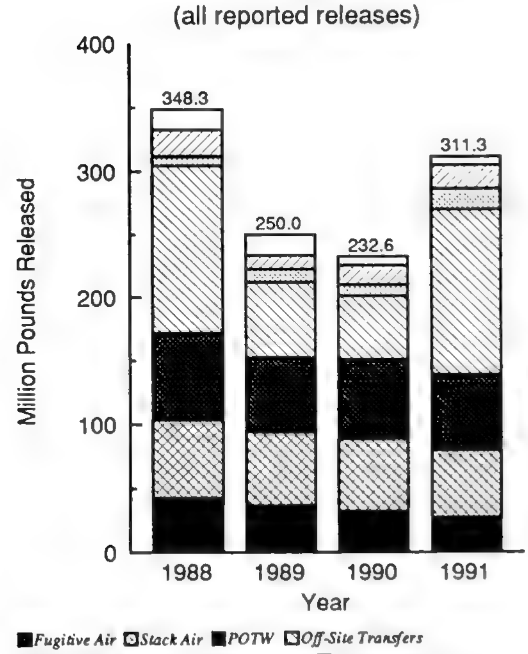
Total Adjusted Illinois TRI Releases
1987-1991



Source: Illinois Toxic Chemical Reports 1987-1991

Figure 10.3

Illinois TRI Releases by Media Group
1988-1991
(all reported releases)



Source: IEPA Annual Toxic Chemical Reports 1988-1991

Figure 10.4

recovery information. Adjusting for the chemicals delisted before 1991 and those added to the inventory in 1991, the trend in total releases is more constant (see Figure 10.3). Adjusting for delisted chemicals allows for comparison of prior years data with that of successive years.

The adjusted figures demonstrate a steady decline in the pounds of chemical released per Illinois reporting facility until 1990 and then an increase in 1991 (Table 10.3). In 1990, Illinois facilities released an average of 177,386 pounds of toxic chemicals as compared with a 1989 nationwide average of 252,810 pounds released per facility (USEPA, 1991). In 1991, Illinois releases per facility reached 237,911 pounds. The increase in 1991 is again explained by the change in reporting requirements. The publicity associated with the Toxic Release Inventory has inspired some companies to reduce the release of toxic chemicals. Firms across the state have also begun to implement pollution prevention techniques in response to regulatory and economic pressures.

Table 10.3. Illinois TRI: Adjusted Releases Per Facility 1987-1991

Year	Number Reporting Facilities	Adjusted Release Per Facility (pounds)
1987	938	275,523
1988	1,174	211,684
1989	1,274	194,264
1990	1,305	177,386
1991	1,301	237,911

Source: IEPA Annual Toxic Chemical Reports, 1987-1991.

Hydrochloric acid was released in the largest quantity, 35,610,833 million pounds, for reporting year 1991. Table 10.4 lists the ten chemicals released and transferred in Illinois during 1991 of the largest volume and the amount of each released in 1990, 1989 and 1988. The releases of these 10 chemicals have consistently ranked highest.

TRI requires multi-media reporting of listed chemicals in seven different categories: stack emissions, fugitive air emissions, water releases, POTW discharges, on-site underground injection, on-site land releases and transfers off-site for management. Beginning in 1991, off-site transfers included shipments of waste to recycling or energy recovery facilities. Illinois air releases (stack and fugitive emissions), POTW discharges and off-site transfers comprise large portions of TRI releases through 1991. In 1990, combined air releases accounted for 88.1 million pounds (38%) of all TRI chemicals released. In 1991, off-site transfers grew to 131 million pounds or 42.2% of the total from a low of 50 million pounds (21.5%) in 1990. Table 10.5 lists the pounds released by category for 1988-1991 and the percentage each media group represented of the total.

Compared to national statistics for 1989, Illinois discharges to POTW's and other off-site transfers were above average but used air emissions (fugitive and stack) and underground releases were less than average.

Since TRI reporting began, releases to certain environmental media in Illinois have remained consistent; air releases, POTW discharges and other off-site transfers have been the most common as illustrated in Figure 10.4.

While statewide TRI releases occur consistently via air, POTW or off-site transfer, some chemicals are more commonly released to one media than the others. This diversity is demonstrated by examining the top chemicals released in each category. In some cases, releases for a particular category are dominated by one chemical. In other cases, a variety of chemicals are released to a particular category. The following discussion identifies the top chemicals released in Illinois to each category group during 1990. A comparison is made with 1988 releases, since 1988 is the base for 33/50 program and the second year's data are thought be more accurate than the 1987 data.

Table 10.4. Top 10 TRI Chemicals Released in Illinois 1991 Compared to Prior Years

Chemical Name	1991 Pounds	1990 Pounds	1989 Pounds	1988 Pounds
Hydrochloric Acid	35,610,833	31,728,725	31,496,075	30,833,433
Zinc and Compounds	31,619,452	19,507,838	19,682,493	20,874,029
Sulfuric Acid	26,274,637	13,175,956	11,514,250	14,684,462
Copper and Compounds	23,967,376	3,576,511	3,288,829	2,703,965
Toluene	16,572,636	14,665,670	19,104,931	21,321,529
Ammonia	15,836,696	16,267,291	6,164,411	7,895,666
Manganese and Compounds	14,671,877	8,750,680	7,454,842	4,991,907
Methanol	14,081,016	9,275,024	10,260,856	9,705,863
Ammonium Sulfate	13,182,016	18,469,617	33,182,632	29,491,078
Xylene (Mixed Isomers, M-,O-,P-)	12,958,000	8,050,866	10,103,907	9,462,123

Source: IEPA Annual Toxic Chemical Reports, 1988-1991.

Table 10.5: Illinois TRI Releases By Media Type (million pounds)

Media Type	1991 qty	1991%*	1990 qty	1990%*	1989 qty	1989%*	1988 qty	1988%*
Fugitive Air	27.2	8.73	32.2	13.8	39.9	14.8	43.0	12.4
Stack Air	52.3	16.81	55.9	24.1	57.1	22.8	60.6	17.4
POTW	59.2	19.01	62.6	26.9	58.2	23.3	68.3	19.6
Off-Site Transfers	131.4	42.20	50.0	21.5	59.7	23.9	132.3	38.0
Land Releases	18.6	5.97	15.4	6.61	10.6	4.3	20.7	5.9
Underground Injection	16.2	5.20	9.4	4.1	10.7	4.3	7.4	2.1
Water Releases	6.5	2.07	7.1	3.1	16.8	6.7	16.0	4.6

* Percentages may not add to 100 due to rounding.
Source: IEPA Annual Toxic Chemical Reports, 1988-1991.

Fugitive Air Releases

Toluene and 1,1,1-trichloroethane topped the list of chemicals released via fugitive air in 1990. These two chemicals accounted for over 11.2 million pounds or 35% of all fugitive air releases (Table 10.6). The top five chemicals released via fugitive air comprise over 57% of all fugitive air releases. The remaining 43% came from a mixture of the remaining TRI chemicals.

Stack Air Releases

As is the case for fugitive air emissions, toluene was the chemical released in the largest amount via stack air with 6.8 million pounds or 12.3% of all stack air releases (Table 10.7). The other chemicals in the top five, xylenes, carbon disulfide, chlorine, 1,1,1-trichloroethane were released in approximately equal amounts in 1990 ranging from 6.52 to 8.45%. Emissions for some of these have increased since 1988, emissions for others have declined.

Water Discharges

Illinois water releases in 1990 were dominated by one chemical, ammonia, with 4.86 million pounds released comprising 68% of all water discharges (Table 10.8). Chemicals discharged to water seem to have fluctuated dramatically since 1988 with no clear trend. The top five chemicals discharged to water accounted for over 96% of all water discharges. It must be noted that in 1990, USEPA gave TRI facilities the option of reporting ammonium sulfate (solution) either as ammonium sulfate (solution) or as ammonia. One Illinois facility chose to report its 1990 release of ammonium sulfate (solution) as ammonia accounting for a large portion of the increase in ammonia releases in 1990.

Table 10.6. Top Five Chemicals Released Via Fugitive Air

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Toulene	5,844,785	18.2	10,066,598	-41.9
1,1,1-Trichloroethane	5,475,499	17.3	6,493,787	-15.7
Ammonia	2,706,669	8.4	4,023,217	-32.7
Methyl Ethyl Ketone	2,218,535	6.9	1,850,341	19.9
Xylene (Mixed Isomers,M-,O-)	2,018,323	6.3	2,457,007	-17.9

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Table 10.7. Top Five Chemicals Released Via Stack Air

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Toulene	6,854,196	12.3	8,055,799	-14.9
Xylene (Mixed Isomers,M-,O-)	4,727,770	8.5	4,691,306	0.8
Carbon Disulfide	4,101,900	7.3	4,306,193	-4.7
Chlorine	4,066,175	7.3	2,053,578	98.0
1,1,1-Trichloroethane	3,646,733	6.5	2,959,199	23.2

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Table 10.8. Top Five Chemicals Released Via Water Discharges

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Ammonia	4,858,870	68.3	1,009,680	381.2
Ammonium Sulfate (Solution)	898,218	12.6	12,250,300	-92.7
Sulfuric Acid	721,302	10.1	386,234	86.8
Phosphoric Acid	197,229	2.8	125,591	57.0
Ethylene Glycol	173,923	2.5	174,930	0.6

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

POTW Releases

Over 80% of POTW releases consisted of the top five chemicals listed in Table 10.9. Hydrochloric acid and Ammonium Sulfate (solution) each accounted for more than 25% of total POTW releases, 17.6 and 17.5 million pounds respectively. The release of these two chemicals has not changed dramatically in total volume since 1988.

Underground Injection

More than any other category, underground injection was dominated by one chemical, hydrochloric acid, accounting for 9.3 million pounds or over 98% of all TRI underground injection releases (Table 10.10). Hydrochloric acid was also the primary chemical injected in 1988. Sulfuric acid was the only other chemical injected in a sizable quantity, still only amounting to 1.7% of the total.

Table 10.9. Top Five Chemicals Released Via POTW

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Hydrochloric Acid	17,615,899	28.2	18,388,594	-4.2
Ammonium Sulfate (Solution)	17,509,610	28.0	17,205,764	1.8
Sulfuric Acid	8,823,226	14.1	9,808,333	-10.0
Ammonia	4,455,897	7.1	1,087,638	309.7
Methanol	3,716,997	5.9	2,954,810	25.8

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Table 10.10. Top Five Chemicals Released Via Underground Injection

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Hydrochloric Acid	9,258,791	98.3	7,158,140	29.4
Sulfuric Acid	160,020	1.7	110,000	45.5
Chlorine	1,344	< 0.1	2,000	-32.8
Arsenic and Compounds	1,250	< 0.1	21,700	-94.2
Zinc and Compounds	1,009	< 0.1	999	1.0

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Land Releases

The biggest distinction between land releases and releases to other categories is the fact that land releases are dominated by metals and metal compounds in contrast with media groups previously discussed. Zinc and zinc compounds accounted for almost 50%, 7.7 million pounds, of the TRI chemicals released to land (Table 10.11). Of the top five chemicals released to land, four are considered metals.

Off-Site Transfer

Off-site TRI transfers have been difficult to analyze, especially before 1991, because it was not clear how these chemicals are ultimately released to the environment. If not reused, off-site transfers will ultimately be released to land, air or water at the site to which they are transferred. The category represents a mixture of different types of releases of a variety of chemicals. The top chemical group in 1990, zinc and zinc compounds, contributed the largest share, 7.67 million pounds (21.68%) of total transfers (Table 10.12). Many other chemicals are released in smaller amounts. Metal compounds dominate the list of off-site transfers.

The 1991 TRI report provides some detailed information about the ultimate fate of chemicals transferred off-site. Approximately 131.4 million pounds of TRI chemicals were transferred off-site in 1991, an increase from 50 million pounds in 1990. The bulk of this increase is attributed to the change in reporting requirements to include recycling and energy recovery. Metals, energy and solvent/organics recovery were the most common methods used in off-site transfers followed by landfills/surface impoundments. Table 10.13 lists the 1991 off-site transfers by management method used. The top chemicals transferred off-site in 1991 will reflect the fact that recycling was most common. TRI chemicals that lend themselves to recycling methods will be reported transferred in the highest quantity.

Table 10.11. Top Five Chemical Releases Via Land Releases

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Zinc and Compounds	7,667,061	49.9	5,872,509	30.6
Manganese and Compounds	4,411,807	28.7	1,234,019	257.5
Ammonia	759,618	4.9	1,978	38303.3
Chromium and Compounds	552,007	3.6	246,638	123.8
Lead and Compounds	520,588	3.4	413,127	26.0

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Table 10.12. Top Five Chemical Releases Via Off-Site Transfer

Chemical	1990 Releases	% Total	1988 Releases	% Change 1988-1990
Zinc and Compounds	10,846,095	21.7	12,216,365	-11.2
Manganese and Compounds	4,116,279	8.2	3,499,008	17.6
Barium and Compounds	3,421,398	6.8	2,557,581	33.8
Copper and Compounds	3,340,672	6.7	2,279,912	46.5
Methanol	3,301,472	6.6	3,612,347	-8.6

Source: IEPA Annual Toxic Chemical Reports, 1988, 1990.

Table 10.13. 1991 Off-Site Illinois TRI Transfers by Management Method

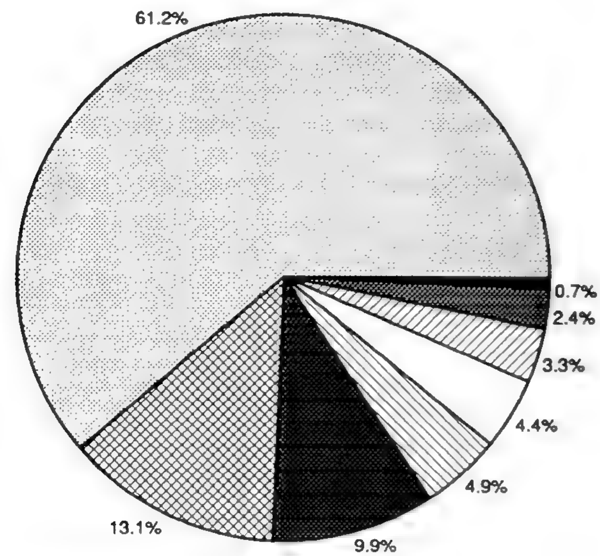
Management Method	Millions Pounds Transferred
Metals Recovery	43.9
Energy Recovery	21.8
Solvents/Organics Recovery	19.4
Landfill/Disposal Surface Impoundment	17.7
Incineration/Thermal Treatment	6.4
Other Reuse/Recovery	4.5
Transfer to Waste Broker - Recycling	4.5
Wastewater Treatment	2.9
Transfer to Waste Broker - Energy Recovery	2.2
Incineration - Insignificant Fuel Value	2.0
Solidification/Stabilization	1.2
Other Waste Treatment	1.2
Acid Regeneration	.5
Underground Injection	.5
Transfer to Waste Broker - Disposal	.3
Other Land Disposal	.2
Storage Only	.1
Transfer to Waste Broker - Waste Treatment	.05
Land Treatment	.04

Source: Fifth Annual Toxic Chemical Report, IEPA/ENV/93-005.

Source Reduction

Beginning in 1991, TRI facilities were required to submit information pertaining to the source reduction methods used in their operations. Of the reports filed by 1301 separate facilities, 453 indicated that source reduction activities had been undertaken to reduce the level of TRI releases (IEPA, 1993). Actual reductions resulting from these activities were estimated to total 14.17 million pounds between 1990 and 1991. Process modifications accounted for 8.67 million pounds of the 14.17 million pounds in reductions. Figure 10.5 displays the frequency with which different methods were used for attaining reductions.

1991 Illinois TRI Source Reduction Data
Percentage of Reductions By Type



Source: IEPA, 1993. IEPA/ENV/93-005.
Figure 10.5

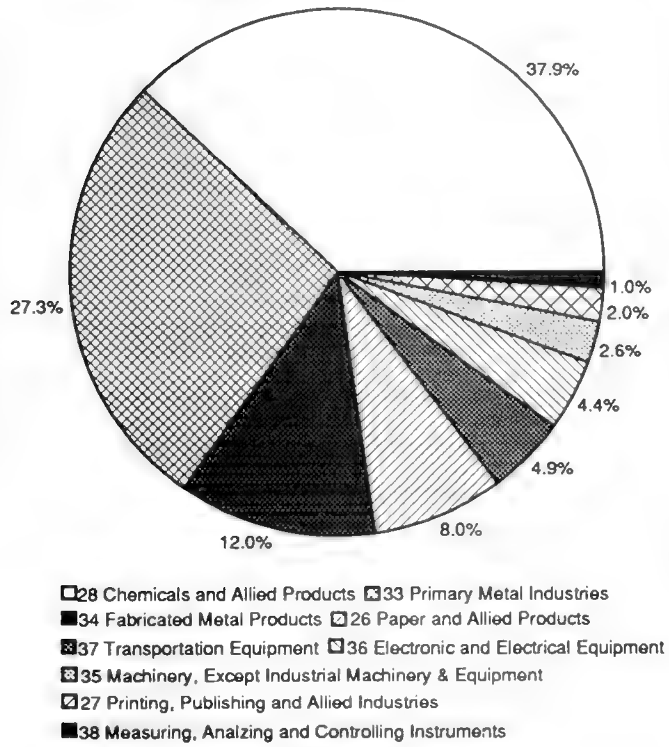
The chemicals and allied products industry accounted for 5.29 million pounds (37.3%) of reported reductions. The primary metals industry and fabricated metals industry reduced TRI releases by 3.81 million and 1.67 million pounds respectively. Figure 10.6 shows the industry breakdown of source reduction efforts.

33/50 PROGRAM CHEMICALS

The 33/50 Program is a USEPA initiative designed to reduce chemical releases to the environment. In 1991, the USEPA asked over 600 American companies to voluntarily reduce releases and transfers of 17 high-priority toxic chemicals (USEPA, 1991). The program aimed for reduction of these 17 chemicals by 33% by the end of 1992 and 50% by the end of 1995. USEPA will use the 1988 TRI database as the basis for identifying reductions.

The 17 priority chemicals for the 33/50 program were selected based on their health and environmental effects, possibility of exposure, volume of production/release and potential for pollution prevention. Table 10.14 lists the seventeen chemical

1991 TRI Source Reduction Efforts by Industry
Percent Total Pounds Reduced



Source: IEPA, 1993. IEPA/ENV/93-005.
Figure 10.6

groups included in the program. The 33/50 program overlaps with the Clean Air Act Amendments of 1990 (CAA) as air emissions accounted for over 70% of releases and transfers of the 17 priority chemicals. USEPA envisions that the CAA and the 33/50 program will work together to promote pollution prevention among US industrial facilities.

At least 101 Illinois companies are participating in the 33/50 program and represent a variety of industries. They are located primarily in the metropolitan areas of the state. Using TRI data, trends can be observed in the release and transfer of 33/50 chemicals. This analysis includes releases for all TRI facilities, some of which are not participating in the program. Reductions in the release and transfer of 33/50 chemicals are expected to be driven by facilities participating in the voluntary program. The current statewide trends may provide an indication of the future success of the program.

Total releases of 33/50 chemicals in Illinois declined until 1990 but then increased to 77.5 million pounds in 1991. 33/50 releases account for approximately 25% of all TRI releases in Illinois (Figure 10.7). Table 10.15 lists all of the 33/50 program chemicals or chemical groups, total pounds released in 1988,

Table 10.14. EPA 33/50 Program Chemicals

33/50 Chemical Class	33/50 Chemical Name
Metals and Metal Compounds	Cadmium and Compounds
	Chromium and Compounds
	Lead and Compounds
	Mercury and Compounds
	Nickel and Compounds
Non-Halogenated Organics	Benzene
	Methyl Ethyl Ketone
	Methyl Isobutyl Ketone
	Toluene
	Xylenes
Halogenated Organics	Carbon Tetrachloride
	Chloroform
	Methyl Chloride
	Tetrachloroethylene
	1,1,1-Trichloroethane
	Trichloroethylene
Cyanides	Cyanides

Source: Toxics in the Community, EPA 560/4-91-014.

1990 and 1991, the percentage each chemical represents of all 33/50 releases and the change in total pounds released between 1988 and 1991.

Toluene is the 33/50 chemical released in the largest amount accounting for over 16.5 million pounds or 21.4% of 1991 33/50 chemical releases. Toluene releases have also seen the greatest reduction since 1988, 4.75 million pounds from 21.3 million pounds in 1988.

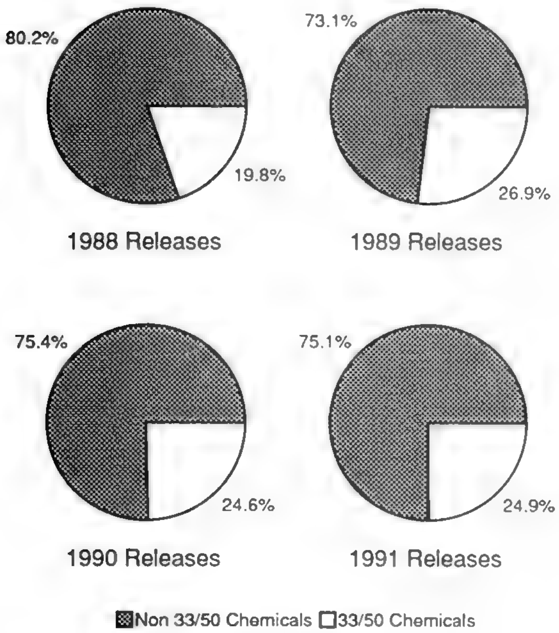
Releases of 33/50 chemicals in Illinois most often occur in four TRI media groups: Fugitive Air Emissions, Stack Air Emissions, Off-Site Transfers and POTW Releases, together accounting for over 95% of all 33/50 releases in 1990.

Table 10.15. 33/50 Program Chemical Releases 1988, 1990 and 1991 (Pounds Released)

Chemical	1988 Pounds	%	1990 Pounds	%	1991 Pounds	%	% Change (88-91)
Benzene	1,839,052	2.67	1,966,601	3.43	1,255,725	1.62	-583,327
Methyl Ethyl Ketone	6,851,787	9.95	6,552,908	11.44	9,014,632	11.63	2,162,845
Methyl Isobutyl Ketone	2,454,222	3.56	1,628,277	2.84	2,642,022	3.41	187,800
m-Xylene	55,999	0.08	135,815	0.24	26,334	0.03	-29,665
o-Xylene	82,995	0.12	66,101	0.12	62,012	0.08	-20,983
Toluene	21,321,529	30.96	14,665,670	25.59	16,572,636	21.38	-4,748,893
Xylenes (Mixed Isomers)	9,323,129	13.54	7,848,950	13.70	12,869,654	16.60	3,546,525
Cadmium & Compounds	126,212	0.18	50,460	0.09	127,924	0.17	1,712
Chromium & Compounds	1,914,674	2.78	1,991,909	3.48	3,488,666	4.50	1,573,992
Lead & Compounds	3,028,034	4.40	2,874,334	5.02	7,552,583	9.74	4,524,549
Mercury & Compounds	85	0.00	14	0.00	7,238	0.01	7,153
Nickel & Compounds	853,944	1.24	742,467	1.30	1,883,623	2.43	1,029,679
1,1,1-Trichloroethane	10,349,854	15.03	9,760,989	17.03	9,221,908	11.90	-1,127,946
Carbon Tetracholride	65,644	0.10	26,490	0.05	112,755	0.15	47,111
Chloroform	68,725	0.10	54,615	0.10	157,938	0.20	89,213
Methylene Chloride (Dichloromethane)	4,328,598	6.29	3,613,661	6.31	6,609,877	8.53	2,281,279
Tetrachloroethylene	1,633,774	2.37	1,180,584	2.06	1,080,394	1.39	-553,380
Trichloroethylene	4,444,963	6.45	3,776,562	6.59	4,540,575	5.86	95,612
Cyanide & Compounds	98,872	0.14	367,112	0.64	289,441	0.37	190,569
Hydrogen Cyanide	18,775	0.03	658	0.00	29	0.00	-18,746
Total 33/50 Releases	68,860,867		57,304,177		77,517,957		8,657,090
Total all TRI Releases (Adjusted)	348,312,023		232,608,507		311,272,245		
% 33/50 of Total TRI Releases		27.56		24.63		24.9	

Source: Illinois EPA Annual Toxic Chemical Reports 1988, 1989, 1990, 1991.

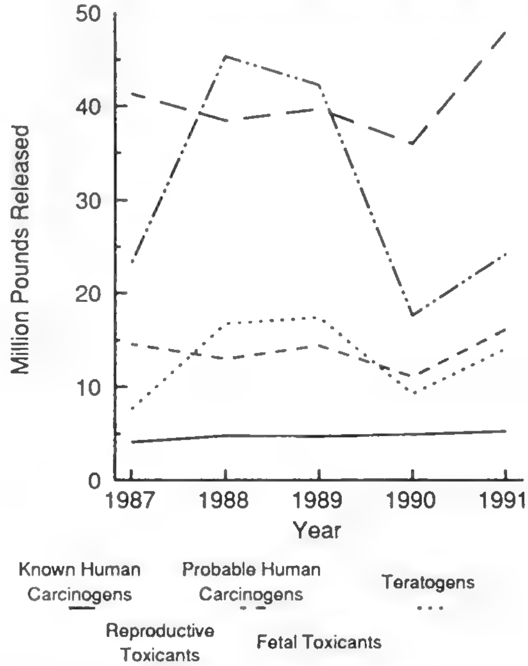
Illinois TRI Releases 1988-1991
33/50 Chemical Releases as Percentage of Total



Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990.

Figure 10.7

Illinois Toxic Release Inventory
Summary of Releases for Health Effects Groups



Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990, 1991

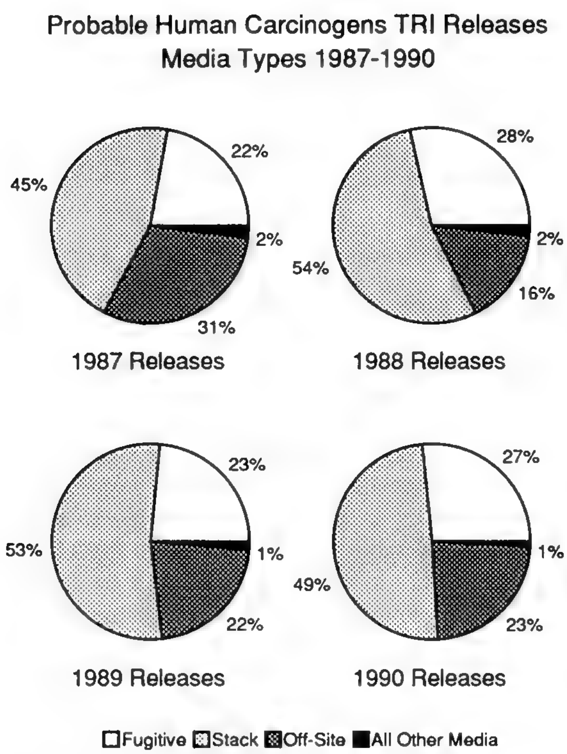
Figure 10.8

HEALTH EFFECTS GROUPS

EPCRA section 313 was designed to inform the public about toxic chemicals which are released in their community. IEPA has produced chemical information sheets for some EPCRA 313 chemicals to educate people about the toxicological aspects of chemical releases. In addition, the chemicals being released in Illinois have been documented as potentially causing various health effects (IEPA, 1992). Some chemicals are considered known human carcinogens (KHC), probable human carcinogens (PHC), teratogens, reproductive toxicants and/or fetal toxicants. The totals for these categories are not exclusive; one chemical may fall into more than one category. IEPA grouped TRI chemical releases by these human health effect categories for the purpose of analysis. Figure 10.8 demonstrates the overall trend in the release of chemicals for the five health effects groups. When evaluating such health category data, it is important to remember that exposure to these toxic chemicals depends on a number of site-specific environmental conditions in the geographic area of release, and that these issues are not addressed in TRI.

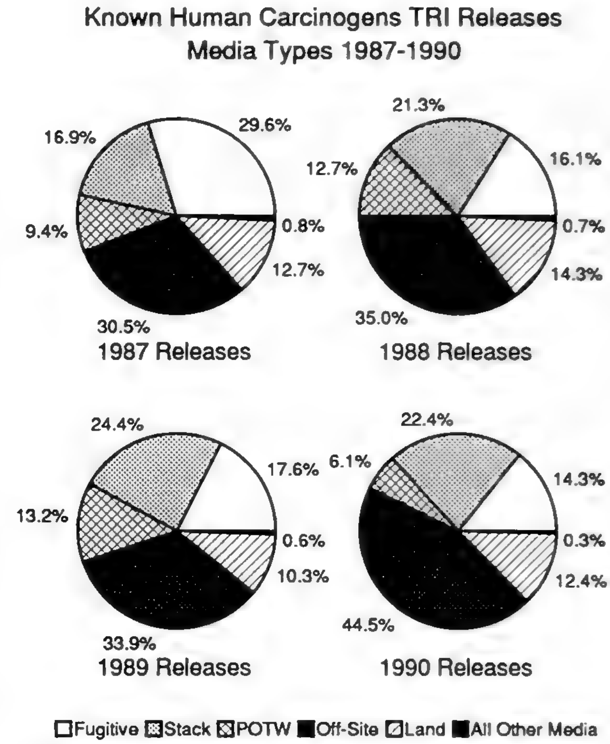
The releases in these health effects groups have fluctuated since 1987. The increased releases during 1988-1989 may be explained by changes to the minimum threshold values required for reporting. The 1990-1991 increase is the result of overall increases in that year due to the expansion of the off-site transfer category. Most health effects groups other than KHC showed dramatic fluctuations in chemicals released.

There are some differences among the health effect groups with regard to the media which chemicals were released between 1987 and 1990. Air emissions (fugitive and stack) and off-site transfers were common for all groups. Releases to POTW's were common for KHC's, teratogens and for reproductive toxicants to a lesser extent. Land releases are substantial for only the KHC and reproductive toxicant groups. Figures 10.9 through 10.13 display the releases by type in reporting years 1987-1990 for each health effect group. Trends can be observed for some of the media categories. For example, off-site transfers of KHC's were more common in 1990 than in 1987 (Figure 10.9). Trends are observed in air emissions for some other categories. Releases to fugitive air have declined for KHC, reproductive toxicant and fetal toxicant releases. The observation of such trends may be useful for regulatory purposes or identifying topics warranting toxicological research in the future.



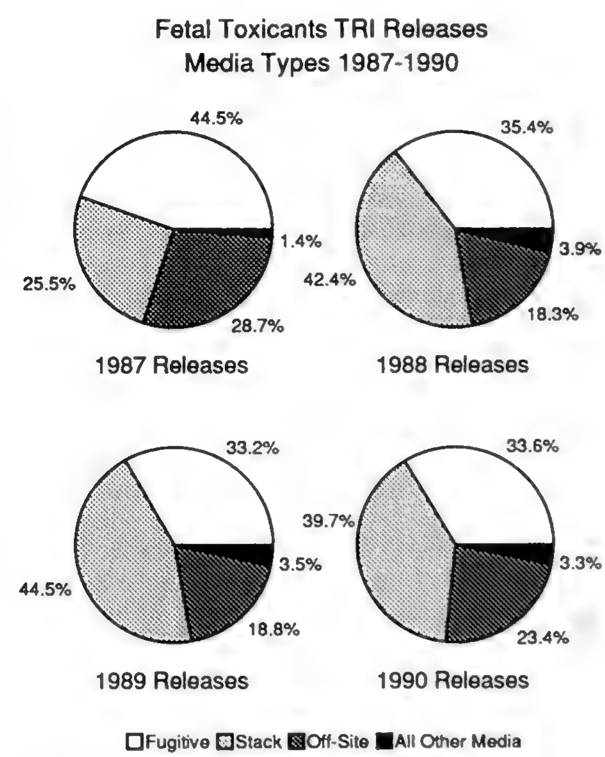
Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990

Figure 10.10



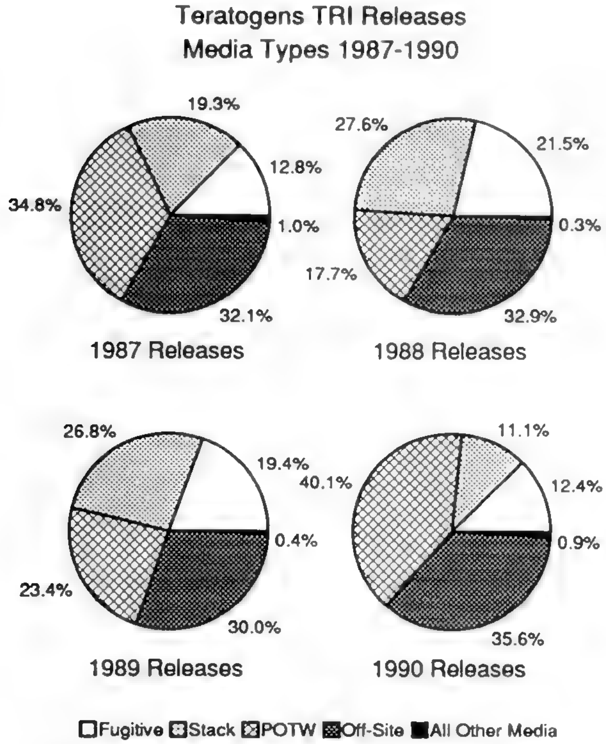
Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990

Figure 10.9



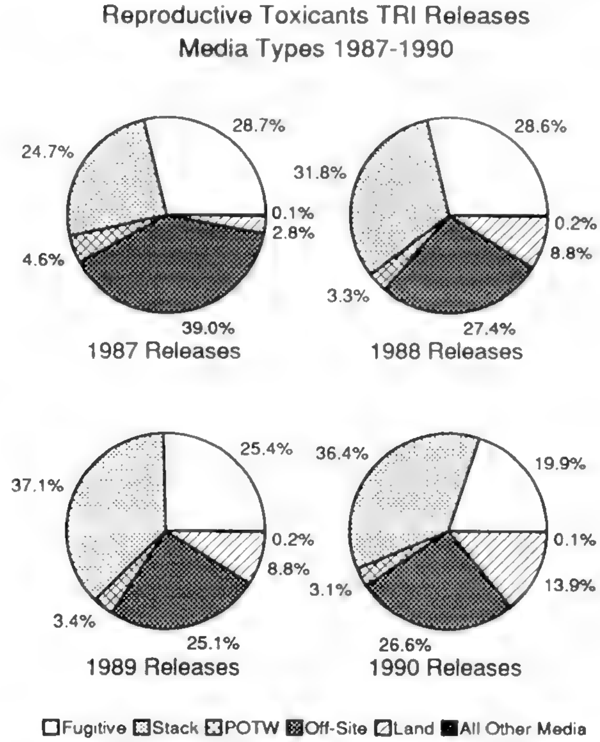
Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990

Figure 10.11



Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990

Figure 10.12



Source: Illinois EPA Annual Toxic Chemical Reports 1987, 1988, 1989, 1990

Figure 10.13

INDUSTRIES REPRESENTED IN TRI REPORTING

The chemical and metals industries have consistently been major contributors of TRI chemicals in Illinois. Over 65% of total TRI chemicals released in 1991 were from two industry groups, Chemicals and Allied Products (SIC 28) and Primary Metal Industries (SIC 33), with 117.8 million pounds (37.85%) and 85.9 million pounds (27.59%) of total releases respectively. The remaining 35% was released by facilities in seventeen other major industry groups required to report under section 313.

The distribution of the number of TRI facilities by industry group is slightly different than total releases. Of the 1301 facilities reporting in 1991, the largest percentage were from the chemical industry (22.52 %), followed closely by the Fabricated Metal Products industry with 21.5%. Fabricated metal products includes electroplating facilities which are numerous in Illinois. Table 10.16 lists the major industry groups, number of facilities and pounds released in Illinois for the 1991 TRI reporting year.

Standard Industrial Classification Codes (SIC) help identify industries as specifically and consistently as possible. Two-digit codes broadly categorize industries and 4-digit codes provide an additional level of detail. Illinois TRI releases have been categorized by 4-digit code to provide more descriptive information about TRI industries. One would expect similarities among facilities with the same 4-digit SIC code with regard to industrial process and toxic chemicals released.

Since 1987, the top 30 4-digit SIC code industries have accounted for 80 to 86% of total TRI pounds released and approximately 40% of the reporting facilities. Table 10.17 lists the top 15 4-digit industry groups in Illinois reporting for 1991, number of facilities and pounds released. Ten Illinois facilities in the steel works industry (SIC 3312) released over 31.5 million pounds of TRI chemicals in 1991. The steel industry has consistently been near the top of the list of industries releasing TRI chemicals. This is also the case for most of the top 15 releasing industries in 1991. Table 10.18 shows the top fifteen 4-digit SIC categories for 1987, 1988, 1989, 1990 and 1991. These industries have consistently been the top releasers of TRI chemicals.

Table 10.16. TRI Releases by Major Industry Group-1991

Industry Group	# Facilities	%	Pounds	%
28 Chemicals and Allied Products	293	22.52	117,809,406	37.85
33 Primary Metal Industries	134	10.30	85,881,084	27.59
34 Fabricated Metal Products	279	21.45	23,060,857	7.41
20 Food and Kindred Products	101	7.76	13,971,134	4.49
30 Rubber and Miscellaneous Plastics Products	88	6.76	15,283,605	4.91
27 Printing Publishing and Allied Industries	29	2.23	7,749,311	2.49
37 Transportation Equipment	49	3.77	12,380,599	3.98
36 Electronic and Other Electrical Equipment	94	7.23	13,889,302	4.46
26 Paper and Allied Products	32	2.46	4,779,697	1.54
35 Industrial and Commercial Machinery and Computer Equipment	68	5.23	5,313,066	1.71
29 Petroleum Refining and Related Industries	35	2.69	4,085,209	1.31
32 Stone, Clay, Glass and Concrete Products	25	1.92	1,036,471	0.33
24 Lumber and Wood Products	14	1.08	1,274,181	0.41
39 Miscellaneous Manufacturing Industries	22	1.69	948,637	0.30
25 Furniture and Fixtures	9	0.69	1,272,568	0.41
31 Leather and Leather Products	2	0.15	323,642	0.10
38 Measuring, Analyzing and Controlling Instruments	21	1.61	1,626,015	0.52
22 Textile Mill Products	4	0.31	456,492	0.15
23 Apparel and Other Finished Products	2	0.15	130,696	0.04

Source: Fifth Annual Toxic Chemical Report, IEPA/ENV/93-005.

Table 10.17. 1991 Top 15 4-Digit Industry Groups Based on Total Pounds TRI Chemicals Released

SIC	Industry Description	1991 # Facilities	1991 Pounds
3312	Steel Works, Blast Furnaces (including Coke Ovens), Rolling Mills	10	31,546,423
2865	Cyclic Organic Crudes and Intermediates, Organic Dyes and Pigments	6	26,247,695
2821	Plastics Materials, Synthetic Resins, Nonvulcanizable Elastomers	28	21,539,308
2819	Industrial Inorganic Chemicals, NEC	17	20,819,034
3315	Steel Wire and Related Products	13	16,664,312
2851	Paints and Allied Products	65	11,995,788
2869	Industrial Organic Chemicals, NEC	22	10,950,627
3341	Secondary Smelting and Refining of Nonferrous Metals	22	10,273,780
2046	Wet Corn Milling	3	9,597,227
3357	Nonferrous Wiredrawing and Insulating	7	8,951,548
3089	Plastics Products, NEC	16	8,460,000
2831	Chemicals and Allied Products/Drugs	1	8,042,683
3714	Motor Vehicle Parts and Accessories	20	5,697,593
2752	Commercial Printing, Lithographic	15	5,253,402
2843	Chemicals and Allied Products/Surface Active Agents	9	4,485,469

Source: Fifth Annual Toxic Chemical Report, IEPA/ENV/93-005.

GEOGRAPHIC DISTRIBUTION OF TRI FACILITIES AND RELEASES

More TRI facilities are located in the Chicago metropolitan area than in other areas of the state. In 1990, 588 facilities (45.1% of the total) filed TRI reports from Cook County alone. Other counties with a large number of TRI facilities include Winnebago, Kane, Du Page, Lake and Kankakee (Figure 10.14).

Figure 10.15 displays the distribution of total pounds of TRI chemicals reported released by county in 1990. Cook and St. Clair county facilities released the highest volumes of TRI chemicals.

Chicago Metropolitan Area

In 1991, 815 facilities (63 % of the total) reporting from the 6-county Chicago metropolitan area (Cook, DuPage, Lake, Kane, Will and McHenry counties) were responsible for over 115.6 million pounds of TRI chemicals or 37% of the state total. Industry in the Chicago area is diverse as over 190 industry groups (4-digit SIC) released TRI chemicals in the area. The wet corn milling industry (SIC 2046) released the largest volume of TRI chemicals in the Chicago area from one facility. Table 10.19 lists the 10 industry groups releasing the largest amount in the Chicago area, number of facilities per industry and millions of pounds released in 1991.

Madison-St Clair County Metropolitan Area

In 1991, only 50 facilities in the Madison-St. Clair area filed TRI reports (3.8% of the total facilities in the state). This 3.8% of facilities released over 16% of the state total of toxic chemicals. A small number of facilities release large volumes of chemicals in this area. In fact, two chemical industry facilities reported larger releases than any industry group found in the Chicago area. Table 10.20 lists the top 10 industries releasing TRI chemicals in the Madison/St. Clair county area.

A comparison of the Chicago-Metro and Madison-St. Clair county areas reveals some disparities in the

Table 10.18. 15 SIC groups releasing the most TRI chemicals from 1987-1991.

1991	1990	1989	1988	1987
3312	2865	2865	3341	2865
2865	3312	3312	2869	2821
2821	2816	2821	2816	2046
2819	2819	2816	3315	3341
3315	2869	2819	2819	3079
2851	2821	2869	3321	2819
2869	2946	2752	3312	2899
3341	2752	2046	2865	2816
2046	3079	3079	2821	2869
3357	3711	3711	2754	3312
3089	2911	3089	3398	2911
2831	2672	2911	2911	3714
3714	3471	3341	2046	2843
2752	3089	2843	3711	2851
2843	3341	2851	2851	2752

Source: Fifth Annual Toxic Chemical Report, IEPA/ENV/93-005.

number of facilities and total TRI releases. In Chicago, 63% of the state's total facilities release 37% of state's total pounds. Whereas Madison-St. Clair area account for only 3.8% of number of facilities.

Table 10.19. Top 10 Industry Groups Releasing TRI Chemicals in Chicago Metropolitan Area 1991

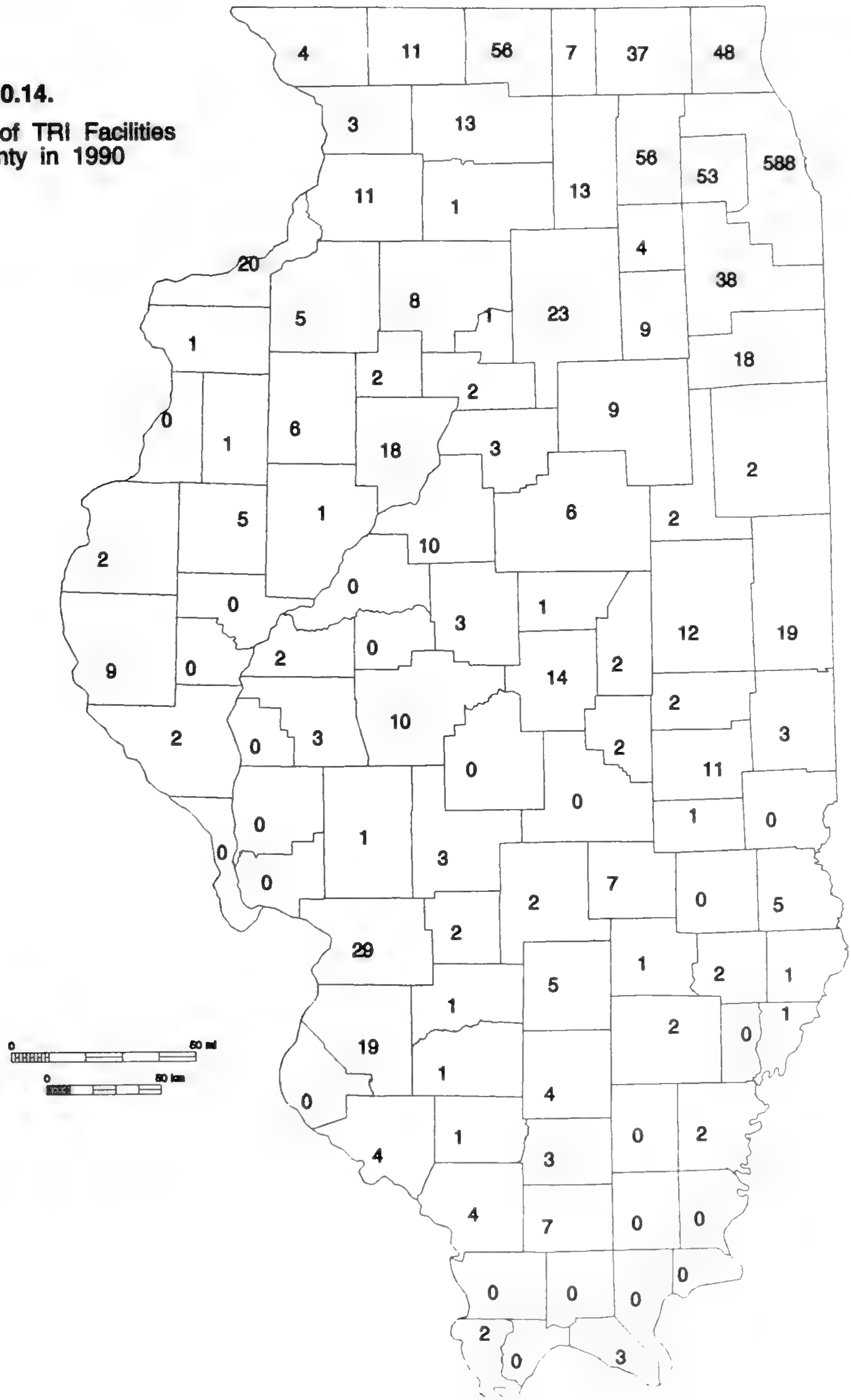
Industry	# Facilities	Millions Pounds Released
2046 Wet Corn Milling	1	8.85
2851 Paints and Allied Products	52	8.77
2831 Drugs	1	8.19
3312 Steel Works, Blast Furnaces, Rolling Mills	7	7.20
3341 Secondary Non-Ferrous Metals	14	4.92
2821 Plastic Materials, Synthetic Resins, Nonvulcanizable Elastomers	14	4.55
2869 Industrial Organic Chemicals, NEC	14	4.29
3089 Plastic Products, NEC	13	4.03
2843 Surface Active Agents	8	3.48
2865 Cyclic Organic Crudes and Intermediates, Organic Dyes and Pigments	4	2.98

Table 10.20. Top 10 Industries Releasing TRI Chemicals in the Madison/St. Clair County Areas

Industry	# Facilities	Millions Pounds Released
2865 Cyclic Organic Crudes and Intermediates, Organic Dyes and Pigments	2	23.27
2869 Industrial Organic Chemicals, NEC	2	5.25
3341 Secondary Smelting and Refining of Nonferrous Metals	3	4.89
3312 Steel Works, Blast Furnaces, Rolling Mills	1	4.59
2816 Inorganic Pigments	1	4.22
3333 Primary Smelting and Refining of Nonferrous Metals	1	1.95
3482 Small Arms Ammunition	1	1.48
2911 Petroleum Refining	2	1.23
3351 Rolling Drawing and Extruding of Copper	1	.79

Figure 10.14.

Number of TRI Facilities Per County in 1990



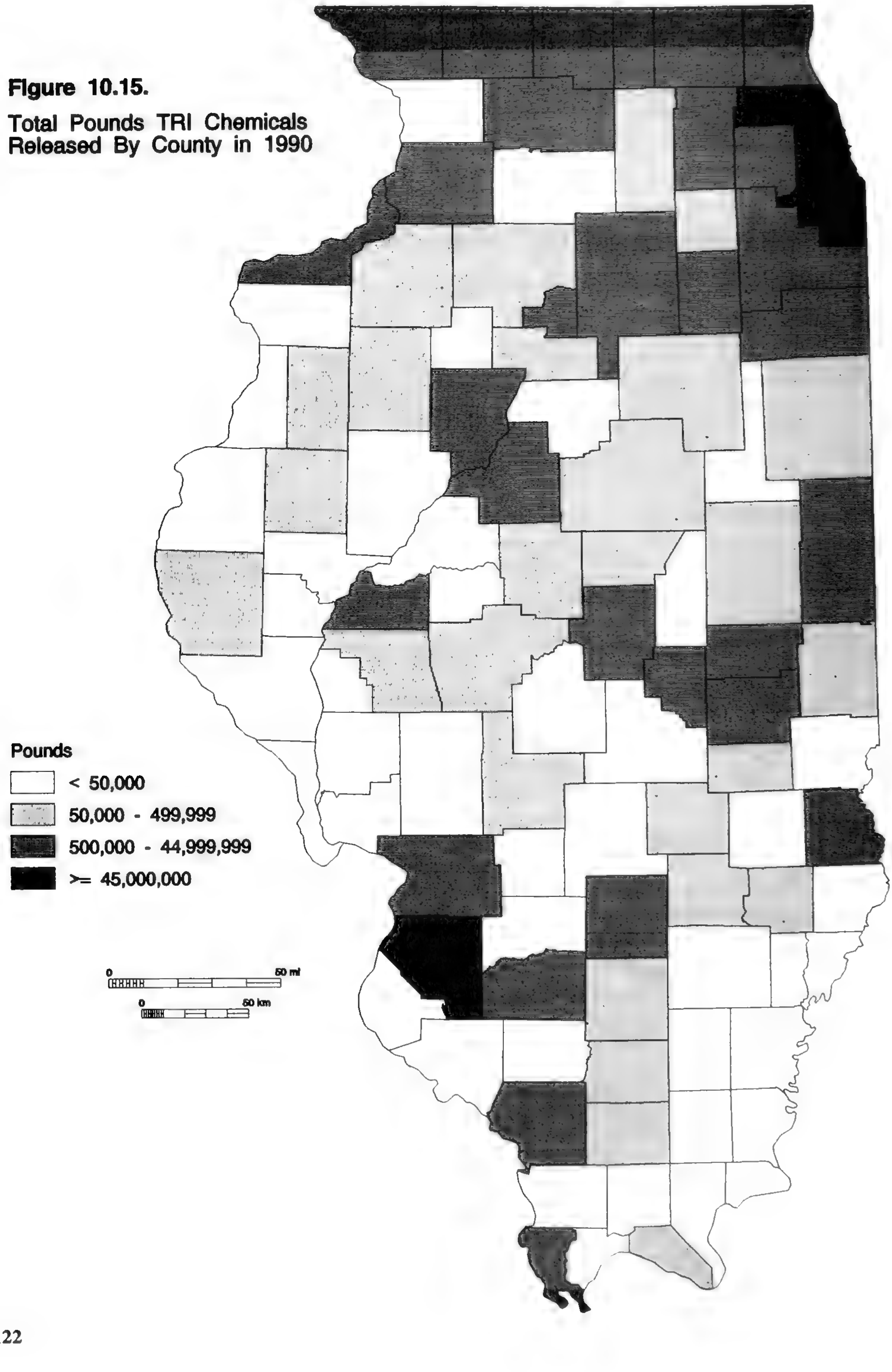


Figure 10.15.

Total Pounds TRI Chemicals Released By County in 1990

SOURCES

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Appendix 10.1: Toxic Release Inventory Chemicals (Ordered By Cas Number)

100-02-7	NITROPHENOL, 4
100-25-4	DINITROBENZENE, p
100-41-4	ETHYLBENZENE
100-42-5	STYRENE MONOMER
100-44-7	BENZYL CHLORIDE
100-75-4	N-NITROSOPIPERIDINE
10034-93-2	HYDRAZINE SULFATE
10049-04-4	CHLORINE DIOXIDE
101-14-4	METHYLENEBIS, 4,4'
101-61-4	METHYLENEBIS BENZENAMINE, 4,4'
101-68-8	METHYLENEBIS
101-77-9	METHYLENEDIANILINE, 4,4'
101-80-4	DIAMINODIPHENYL ETHER, 4,4'
103-23-1	BIS (2-ETHYLHEXYL) ADIPATE
104-94-9	ANISIDINE, p
105-67-9	DIMETHYLPHENOL, 2,4
106-42-3	XYLENE, p
106-44-5	CRESOL, p
106-46-7	DICHLOROBENZENE, 1,4
106-50-3	PHENYLENEDIAMINE, p
106-51-4	QUINONE
106-88-7	BUTYLENE OXIDE, 1,2
106-89-8	EPICHLOROHYDRIN
106-93-4	DIBROMOETHANE, 1,2
106-99-0	BUTADIENE, 1,3
107-02-8	ACROLEIN
107-05-1	ALLYL CHLORIDE
107-06-2	DICHLOROETHANE, 1,2
107-13-1	ACRYLONITRILE
107-18-6	ALLYL ALCOHOL
107-21-1	ETHYLENE GLYCOL
107-30-2	CHLOROMETHYL METHYL ETHER
108-05-4	VINYL ACETATE
108-10-1	METHYL ISOBUTYL KETONE
108-31-3	MALEIC ANHYDRIDE
108-38-3	XYLENE, m
108-39-4	CRESOL, m
108-60-1	BIS (2-CHLORO-1-METHYLETHY ETHER
108-88-3	TOLUENE
108-90-7	CHLOROBENZENE
108-95-2	PHENOL
109-86-4	METHOXYETHANOL, 2
110-80-5	ETHOXYETHANOL, 2
110-82-7	CYCLOHEXANE
110-86-1	PYRIDINE
111-42-2	DIETHANOLAMINE
111-44-4	BIS (2-CHLOROETHYL) ETHER
1120-71-4	PROPANE SULTONE
114-26-1	PROPOXUR
115-07-1	PROPYLENE
115-32-2	DICOFOL
1163-19-5	DECABROMODIPHENYL OXIDE
117-79-3	AMINOANTHRAQUINONE, 2
117-81-7	DI-(2-ETHYLHEXYL) PHTHALATE (DEHP)
117-84-0	DI (n-octyl) PHTHALATE
118-74-1	HEXACHLOROBENZENE
119-33-7	DIMETHYLBENZIDINE, 3,3'
119-90-4	DIMETHOXYBENZIDINE, 3,3'
120-12-7	ANTHRACENE
120-58-1	ISOSAFROLE
120-71-8	CRESIDINE, p
120-80-9	CATECHOL
120-82-1	TRICHLOROBENZENE, 1,2,4
120-83-2	DICHLOROPHENOL, 2,4
121-14-2	DINITROTOLUENE, 2,4
121-69-7	N,N-DIMETHYLANILINE
12122-67-7	ZINEB
122-66-7	DIPHENYLHYDRAZINE
123-31-9	HYDROQUINONE
123-38-6	PROPIONALDEHYDE
123-72-8	BUTYRALDEHYDE
123-91-1	DIOXANE, 1,4
124-73-2	DIBROMOTETRAFLUOROETHANE
12427-38-2	MANEB (Carbamodithioic acid)
126-72-7	TRIS (2,3-DIBROMOPROPYL) PHOSPHATE
126-99-8	CHLOROPRENE
127-18-4	TETRACHLOROETHYLENE
128-66-5	C.I. VAT YELLOW 4
131-11-3	DIMETHYL PHTHALATE
1313-27-5	MOLYBDENUM TRIOXIDE
1314-20-1	THORIUM DIOXIDE
1319-77-3	CRESOL
132-64-4	DIBENZOFURAN
133-06-2	CAPTAN
133-90-4	CHLORAMBEN
1330-20-7	XYLENE
1332-21-4	ASBESTOS
1335-87-1	HEXACHLORONAPHTHALENE
1336-36-3	PLOYCHLORINATED BIPHENYLS (PCBs)
134-29-2	ANISIDINE HYDROCHLORIDE, o
134-32-7	NAPHTHYLAMINE, alpha
1344-28-1	ALUMINUM OXIDE (fibrous form)
135-20-6	CUPFERRON
139-13-9	NITRILOTRIACETIC ACID
139-65-1	THIODIANLINE, 4,4'
140-88-5	ETHYL ACRYLATE
141-32-2	BUTYL ACRYLATE
1464-53-5	DIEPOXYBUTANE
151-56-4	ETHYLENEIMINE (Azridine)
156-10-5	NITROSODIPHENYLAMINE, p
156-62-7	CALCIUM CYANAMIDE
1582-09-8	TRIFURALIN
16071-86-6	C.I. DIRECT BROWN 95
1634-04-4	METHYL TERT-BUTYL ETHER
16543-55-8	N-NITROSONORNICOTINE
1836-75-5	NITROFEN
1897-45-6	CHLOROTHALONIL
1937-7-7	C.I. DIRECT BLACK 38
20816-12-0	OSMIUM TETROXIDE

2164-17-2	FLUOMETURON
2234-13-1	OCTACHLORONAPHTHALENE
2303-16-4	DIALLATE
25321-14-6	DINITROTOLUENE (mixed isomers)
25321-22-6	DICHLOROBENZENE
25376-45-8	DIAMINOTOLUENE
2602-46-2	C.I. DIRECT BLUE 6
26471-62-5	TOLUENEDIISOCYANATE (mixed isomers)
2832-40-8	C.I. DISPERSE YELLOW 3
302-01-2	HYDRAZINE
309-00-2	ALDRIN
3118-97-6	C.I. SOLVENT ORANGE 7
334-88-3	DIAZOMETHANE
3761-53-3	C.I. FOOD RED 5
39156-41-7	DIAMINOANISOLE SULFATE, 2,4
421-01-2	BROMOCHLORODIFLUOROMETHANE (HALON 1211)
4549-40-0	N-NITROSOMETHYLVINYLAMINE
463-58-1	CARBONYL SULFIDE
4680-78-8	C.I. ACID GREEN 3
492-80-8	C.I. SOLVENT YELLOW 34 (Auramine)
50-00-0	FORMALDEHYDE
505-60-2	MUSTARD GAS
51-28-5	DINITROPHENOL, 2,4
51-75-2	NITROGEN MUSTARD
51-79-6	URETHANE
510-15-6	CHLOROBENZILATE
52-68-6	TRICHLORFON
528-29-0	DINITROBENZENE, o
53-96-3	ACETYLAMINOFLUORENE, 2
532-27-4	CHLOROACETOPHENONE, 2
534-52-1	DINITRO-O-CRESOL, 4,6
540-59-0	DICHOROEHYLENE, 1,2
541-41-3	ETHYL CHLOROFORMATE
541-73-1	DICHLOROBENZENE, 1,3
542-75-6	DICHLOROPROPYLENE, 1,3
542-88-1	BIS (CHLOROMETHYL) ETHER
55-18-5	N-NITROSODIETHYLAMINE
55-21-0	BENZAMIDE
55-63-0	NITROGLYCERIN
56-23-5	CARBON TETRACHLORIDE
56-38-2	PARATHION
569-64-26	C.I. BASIC GREEN 4
57-14-7	DIMETHYL HYDRAZINE, 1,1
57-57-8	PROPIOLACTONE, beta
57-74-9	CHLORDANE
58-89-9	LINDANE
584-84-90	TOLUENE-2,4-DIISOCYANATE
59-89-2	N-NITROSOMORPHOLINE
593-60-2	VINYL BROMIDE
60-09-3	AMINOAZOBENZENE, 4
60-11-7	DIMETHYLAMINOAZOBENZENE, 4
60-34-4	METHYL HYDRAZINE
60-35-5	ACETAMIDE
606-20-2	DINITROTOLUENE 2,6
615-05-4	DIAMINOANISOLE, 2,4
62-53-3	ANILIN
62-55-5	THIOACETAMIDE
62-56-6	THIOUREA
62-73-7	DICHLORVOS (Phosphoric acid)
62-75-9	N-NITROSODIMETHYLAMINE
621-64-7	N-NITROSODI-N-PROPYLAMINE
624-83-9	METHYL ISOCYANATE
63-25-2	CARBARYL
636-21-5	TOLUIDINE HYDROCHLORIDE, o
64-67-5	DIETHYL SULFATE
6484-52-2	AMMONIUM NITRATE (solution)
67-56-1	METHANOL
67-63-0	ISOPROPANOL
67-64-1	ACETONE
67-66-3	CHLOROFORM
67-72-1	HEXACHLOROETHANE
68-76-8	TRIAZIQUONE
680-31-9	HEXAMETHYLPHOSPHORAMIDE
684-93-5	N-NITROSO-N-METHYLUREA
71-36-3	BUTYL ALCOHOL, n
71-43-2	BENZENE
71-55-6	TRICHLOROETHANE, 1,1,1
72-43-5	METHOXYCHLOR
74-83-9	BROMOMETHANE (METHYL BROMIDE)
74-85-1	ETHYLENE
74-87-3	CHLOROMETHANE
74-88-4	METHYL IODIDE
74-90-8	HYDROGEN CYANIDE
7429-90-5	ALUMINUM (fune or dust)
7439-92-1	LEAD
7439-96-5	MANGANESE
7439-97-6	MERCURY
7440-02-0	NICKEL
7440-22-4	SILVER
7440-28-0	THALLIUM
7440-36-0	ANTIMONY
7440-38-2	ARSENIC
7440-39-3	BARIUM
7440-41-7	BERYLLIUM
7440-43-9	CADMIUM
7440-47-3	CHROMIUM
7440-48-4	COBALT
7440-50-8	COPPER
7440-62-2	VANADIUM (fume or dust)
7440-66-6	ZINC (fume or dust)
75-00-3	CHLOROETHANE
75-01-4	VINYL CHLORIDE
75-05-8	ACETONITRILE
75-07-0	ACETALDEHYDE
75-15-0	CARBON DISULFIDE
75-21-8	ETHYLENE OXIDE
75-25-2	BROMOFORM (TRIBROMOMETHANE)
75-27-4	DICHLOROBROMOMETHANE
75-35-42	VINYLIDENE CHLORIDE
75-44-5	PHOSGENE
75-55-8	PROPYLENEIMINE
75-56-9	PROPYLENE OXIDE
75-63-8	BROMOTRIFLUOROMETHANE (HALON 1301)
75-65-0	BUTYL ALCOHOL, tert
75-69-4	TRICHLOROFLUOROMETHANE

75-71-8	DICHLORODIFLUOROMETHANE
7550-45-0	TITANIUM TETRACHLORIDE
759-73-9	N-NITROSO-N-ETHYLUREA
76-13-1	FREON 113 (Ethane)
76-14-2	DICHLOROTETRAFLUORETHANE
76-15-3	MONOCHLOROPENTAFLUOROETHANE
76-44-8	HEPTACHLOR
7647-01-0	HYDROCHLORIC ACID
7664-38-2	PHOSPHORIC ACID
7664-39-3	HYDROGEN FLUORIDE
7664-41-7	AMMONIA
7664-93-9	SULFURIC ACID
7697-37-2	NITRIC ACID
77-47-1	HEXACHLOROCYLCOPENTADIENE
77-78-1	DIMETHYL SULFATE
7723-14-0	PHOSPHORUS (white)
7782-49-2	SELENIUM
7782-50-5	CHLORIDE
7783-20-2	AMMONIUM SULFATE (solution)
78-84-2	ISOBUTYRALDEHYDE
78-87-5	DICHLOROPROPANE, 1,2
78-88-6	DICHLOROPROPENE, 2,3
78-92-2	BUTYL ALCOHOL, sec
78-93-3	METHYL ETHYL KETONE
79-00-5	TRICHLOROETHANE, 1,1,2
79-01-6	TRICHLOROETHYLENE
79-06-1	ACRYLAMIDE
79-10-7	ACRYLIC ACID
79-11-8	CHLOROACETIC ACID
79-21-0	PERCETIC ACID
79-34-5	TETRACHLOROETHANE, 1,1,2,2
79-44-7	DIMETHYLCARBAMYL CHLORIDE
79-46-9	NITROPROPANE, 2
80-05-7	ISOPROPYLIDENEDIPHENOL, 4,4'
80-15-9	CUMENE HYDROPEROXIDE
80-62-6	METHYL METHACRYLATE
8001-35-2	TOXAPHENE
8001-58-9	CREOSOTE
81-07-2	SACCHARIN
81-88-9	C.I. FOOD RED 15
82-28-0	AMINO-2-METHYLANTHRAQUINONE, 1
82-68-8	QUINTOZENE
84-66-2	DIETHYL PHTHALATE
84-74-2	DIBUTYL PHTHALATE
842-07-9	C.I. SOLVENT YELLOW 14
85-44-9	PHTHALIC ANHYDRIDE
85-68-7	BUTYL BENZYL PHTHALATE
86-30-6	N-NITROSODIPHENYLAMINE
87-62-7	XYLIDINE, 2,6
87-68-3	HEXACHLORO-1,3-BUTADIENE
87-86-5	PENTACHLOROPHENOL (PCP)
88-06-2	TRICHLOROPHENOL, 2,4,6
88-75-5	NITROPHENOL, 2
88-89-1	PICRIC ACID
90-04-0	ANISIDINE, o
90-43-7	PHENYLPHENOL, 2
90-94-8	MICHLER'S KETONE
91-08-7	TOLUENE-2,6-DIISOCYANATE
91-20-3	NAPHTHALENE
91-22-5	QUINOLINE
91-59-8	NAPHTHYLAMINE, beta
91-94-1	DICHLOROBENZIDINE, 3,3'
92-52-4	BIPHENYL
92-67-1	AMINOBIPHENYL, 4
92-87-5	BENZIDINE
92-93-3	NITROBIPHENYL, 4
924-16-3	N-NITROSODI-N-BUTYLAMINE
94-36-0	BENZOYL PEROXIDE
94-59-7	SAFROLE
94-75-7	D, 2,4 (Acetic acid)
95-47-6	XYLENE, o
95-48-7	CRESOL, o
95-50-1	DICHLOROBENZENE, 1,2
95-53-4	TOLUIDINE, o
95-63-6	TRIMETHYLBENZENE, 1,2,4
95-80-7	DIAMINOTOLUENE, 2,4
95-95-4	TRICHLOROPHENOL, 2,4,5
96-09-3	STYRENE OXIDE
96-12-8	DIBROMO-3-CHLOROPROPANE, 1,2
96-33-3	METHYL ACRYLATE
96-45-7	ETHYLENE THIOUREA
961-11-5	TETRACHLORVINPHOS
97-56-3-6	C.I. SOLVENT YELLOW 3
98-07-7	BENZOIC TRICHLORIDE (Benzotrichloride)
98-82-8	CUMENE
98-87-3	BENZAL CHLORIDE
98-88-4	BENZOYL CHLORIDE
98-95-3	NITROBENZENE
989-38-8	C.I. BASIC RED 1
99-59-2	NITRO-O-ANISIDINE, 5
99-65-0	DINITROBENZENE, M

INTRODUCTION TO WASTE MANAGEMENT ISSUES

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People have dealt with waste management issues ever since permanent settlements came into existence. Industrial and population growth necessitated the adoption of adequate waste management practices to improve and maintain sanitary conditions. Even though experts began to recognize the connection between transmission of disease and sanitary conditions by the mid 1800's, solid waste disposal technology was slow to evolve. The removal of wastes from residential and industrial areas was seen as a high priority and by 1880, 43% of U.S. cities provided collection services for wastes (85% of cities by 1915) (Eldredge Engineering, 1989). Ocean dumping and burning were considered preferred management options until after World War II when air pollution conditions became of greater concern.

Before 1970, solid waste management practices in Illinois, as in most states, were casual and drew little public attention. Anyone could create an open dumpsite on their property by obtaining zoning authorization from the local zoning board or city government. For $25 they could register their site with the Illinois Department of Public Health without any public intervention or design requirements (Wenner, 1987).

On January 1, 1970, President Richard Nixon signed into law the National Environmental Policy Act (NEPA) which set in motion a wave of environmental legislative activity (Wentz, 1989). In that same year, the General Assembly passed the Illinois Environmental Protection Act which created the Illinois Environmental Protection Agency (IEPA) and the Pollution Control Board (PCB). The PCB was designed to set statewide environmental standards for control of air, water and land pollution and to judge violations of these standards. IEPA's job was to enforce those regulations and issue permits including those for pollution control facilities and equipment (IEPA, 1991).

The severity of the waste problem that existed in the early 1970's is demonstrated by the fact that of 250 million tons of residential, commercial and institutional solid wastes produced nationally in 1969, only 190 million tons were collected. The remainder was scattered in backyards, vacant lots and along the roadways. In addition, over 110 million tons of industrial wastes were produced in that year (Brunner, 1972). Statistics such as these and the increasing difficulty in locating proper disposal sites prompted the USEPA to regulate landfill sites and officially recommend sanitary landfilling as an acceptable alternative to open dumping.

In 1979, the Illinois PCB adopted regulations governing special waste to eliminate the unregulated disposal of certain industrial wastes and to provide a practical alternative to sole reliance on the then-existing RCRA hazardous waste guidelines. Special wastes are regulated by the Illinois Environmental Protection Agency (IEPA) and similar data reporting is required regardless of whether the special waste is hazardous or nonhazardous. For example, generators of special wastes are required to report amounts of hazardous and nonhazardous waste shipped to off-site TSD facilities. All special waste treatment, storage and disposal (TSD) facilities in Illinois must secure a permit from IEPA before accepting special wastes. The regulations also require shipments of special waste handled off-site to be manifested.

In 1981, the Illinois General Assembly amended the Environmental Protection Act with Senate Bill 172 (SB 172) to address issues related to siting of waste management facilities. SB 172 assigned the responsibility of approving the location of all new facilities to the county and municipal governments. It was passed at a time when many states were modifying siting procedures for hazardous waste facilities to weaken the authority of local governments. In 1977, only three states had statutes governing the siting of hazardous waste management facilities. By 1988, 41 states had such laws (Houghton, 1989). The Illinois legislature chose to give more decision-making power to local government despite the national trend in response to local governments' desire to assert more control over siting. Previously IEPA controlled the process.

SB 172 created a distinction between regional and local pollution control facilities. Local pollution control facilities are defined as facilities located within the jurisdiction of a unit of government and intended to serve only that unit. These include new water or sewer facilities, as well as all treatment, storage, disposal and recovery (TSDR) facilities located on property owned by an industry and used to manage waste generated only by that industry. Under the law, local pollution control facilities are subject only to zoning or land use approval from the local government.

Regional pollution control facilities (RPCFs) are limited to "any waste storage site, sanitary landfill, waste disposal site, waste transfer station or waste incinerator accepting waste from or serving an area that exceeds or extends over the boundaries of any local general purpose unit of government (Illinois Environmental Protection Act, Section 3.32)." RPCF's are subject to a more public siting approval process than local facilities. Certain facilities are excluded from the definition. The siting provisions are found in Section 39.2 of the Act.

The intent of SB 172 was for citizens to be fully informed in the siting process for a RPCF. A firm wishing to establish a new RPCF, expand an old one, or begin receiving hazardous or special wastes must request approval from either the county board or municipality. Notifications and hearings are required. SB 172 specifies that approval should be made in accordance with the following criteria:

1) the facility is necessary to accommodate the waste needs of the area it is intended to serve;

2) the facility is so designed, located and proposed to be operated that the public health, safety and welfare will be protected;

3) the facility is located so as to minimize incompatibility with the character of the surrounding area and to minimize the effect on the value of the surrounding property;

4) the facility is located outside the boundary of the 100-year flood plain or is flood proofed;

5) the plan or operations for the facility is designed to minimize the danger to the surrounding area from fire, spills or other operational accidents;

6) the traffic patterns to or form the facility are so designed as to minimize the impact on existing traffic flows;

7) if the facility will be treating, storing or disposing of hazardous waste, an emergency response plan for the facility which includes notification, containment and evacuation procedures to be used in case of an accidental release;

8) if the facility will be located within a regulated recharge area, any applicable requirements specified by the PCB for such areas have been met;

9) if the facility is to be located in a county where the county board has adopted a solid waste management plan, the facility is consistent with that plan.

The applicant's previous operating experience and criminal violations in solid waste management may also be considered in the approval criteria (IEPA, 1991).

Development of a new regional pollution control facility involves health, environmental, regulatory, social and economic decisions. Health and environmental considerations are principal concerns in assuring the protection of the public welfare. The geology of the proposed site and the proximity to population centers are issues requiring scientific insight and proper engineering. Regulatory requirements are meant to provide some assurance that these needs are met and that the public interest is represented. The economic interests of the community in siting a new RPCF involve potential revenue from taxes and fees, potential decrease in property value and increase in demands on public emergency response services. Along the same lines, the RPCF developer/operator must consider profits and investments to insure funds for safe maintenance and operation (Members of the Hazardous Waste Dialogue Group, 1983).

Once an applicant for a RPCF has obtained site approval, development and operating permits from IEPA must also be obtained. Permits are required to assure that the facility is properly designed, constructed and operated to minimize pollution and ensure safety. The permit application is reviewed for proper site geology and proper engineering design for leachate control, odor control and groundwater protection among others. Proposed hazardous waste facilities are also subject to federal Resource Conservation and Recovery Act (RCRA) standards

Table 11.1. SB 172 Decisions from November 12, 1981 -July 1, 1992 (IEPA, 1993)

Facility Type	Local Siting Attempts	IEPA Permit
New Landfills	25 Approved 16 Denied 3 Pending 4 Withdrawn 1 No action 27 Appeals	8 Issued 7 Denied 1 Pending 5 Withdrawn
Landfill Expansions	55 Approved 9 Denied 4 Pending 2 Withdrawn 4 No action 26 Appeals	35 Issued 5 Denied 8 Pending
Landfill Modifications	4 Approved	4 Issued
Transfer Stations	27 Approved 9 Denied 3 Pending 4 Withdrawn 6 Appeals	20 Issued 2 Denied
Storage and Treatment	11 Approved 3 Denied 5 Withdrawn 2 Appeals	9 Issued 3 Denied
Incinerators	6 Approved 4 Denied 3 Withdrawn 1 Pending 0 No action 3 Appeals	3 Issued 1 Denied 1 Pending

Source: IEPA Regional Pollution Control Facility Siting in Illinois Nov. 12, 1981-July 1, 1992.

which include minimum technological requirements for design and ground water monitoring (IEPA, 1991). For any permitted facility, the operator must provide a closure and post-closure care plan and demonstrate that financial resources will be available for as many as 30 years after closure for hazardous waste facilities.

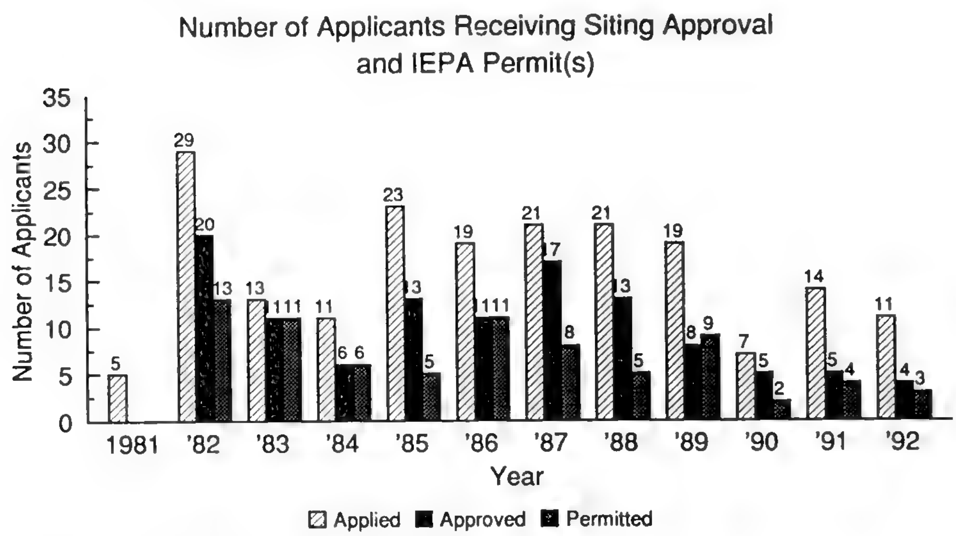
According to 1993 IEPA statistics for siting regional pollution control facilities, local governments have approved the majority of applications since SB 172 took effect in November 1981. (See Table 11.1.) Of the 168 local decisions made through July 1992, 76% of the sites were approved. Of those receiving local approval, 81 received IEPA permits to develop facilities, according to IEPA's 1993 siting report. This siting report includes information for all types of RPCF's, not only landfills.

The trends in siting regional pollution control facilities since SB 172 took effect can be graphically represented. (See Figures 11.1, 11.2 and 11.3.)

Although the rate of application shows no significant decline since 1982, the number of sites receiving approval and permits has fallen as the controversy over waste management options continues to grow.

Approval statistics indicate that it is much easier to expand an existing facility than to site a new one. By June 1990, 51 of the local decisions had been appealed. In the majority of cases, the PCB and the Illinois Appellate and Supreme Courts affirmed the local decision (Monti, 1990).

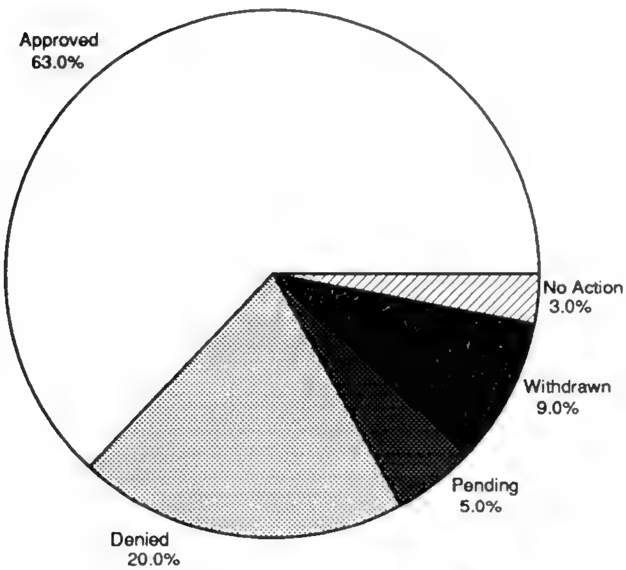
The NIMBY (Not in My Backyard) sentiment among local citizens has been a driving force in blocking the development of new waste management facilities. Concern for dwindling landfill space and frustration over the process lead to several unsuccessful attempts to divert the local control over the approval process to promote swifter development of new facilities (IEC, 1989). Currently, environmentalists and developers have not reached a compromise, and SB 172 continues to provide policy measures for siting.



Source: IEPA, Regional Pollution Control Facility Siting in Illinois, Nov. 12, 1981-July 1, 1992

Figure 11.1

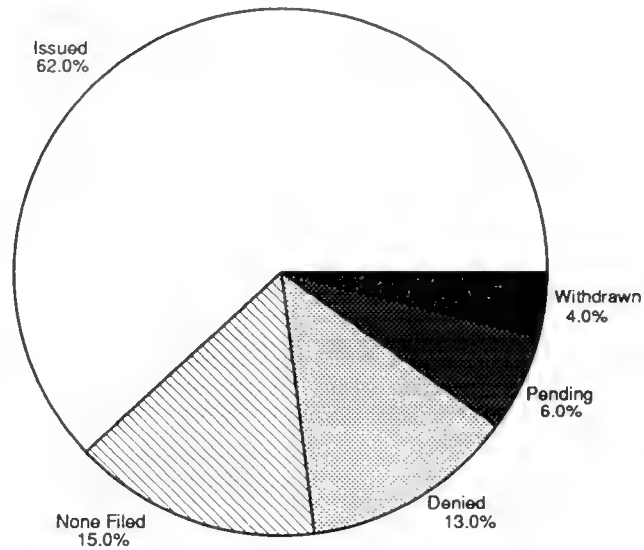
Siting Cases at Local Level of Government
Nov. 12, 1981-July 1, 1992



Source: IEPA, Regional Pollution Control Facility Siting in Illinois 1993

Figure 11.2

IEPA Permitting Action on 128 Approved Sites
Nov. 12, 1981-July 1, 1992



Source: IEPA, Regional Pollution Control Facility Siting in Illinois 1993

Figure 11.3

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LANDFILLS

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Landfilling is one of the oldest and simplest means to manage waste. Landfills are used in all parts of the country and have traditionally been the most popular disposal option; more than 70% of the municipal solid waste is disposed in landfills in the United States (Suflita, 1992). The use of landfills has historically been the most economical means to handle refuse, largely because environmental and safety concerns were not addressed.

The sanitary landfill was not used in this country during the late 19th and early 20th centuries. "Open Dumping" in which garbage was simply piled and often burned was the most frequently used practice. Although the sanitary landfill technique developed around 1910 was more sophisticated, it was not immediately adopted because it was more expensive than open dumping and burning (Eldredge Engineering, 1989). Despite this potentially more effective and less environmentally threatening technique, solid waste management in this country was generally a neglected topic until the adoption of comprehensive environmental regulations. As recently as 1972, open dumping and burning were commonly used throughout the United States. Excessive open dumping and the increasing difficulty in locating proper disposal sites prompted the USEPA to regulate landfills and officially recommend sanitary landfilling as an alternative to open dumping. Eventually, the sanitary landfill became the only land disposal option for many wastes.

Sanitary landfilling is defined by the American Society of Civil Engineers as:

> "A method of disposing refuse on land without creating nuisances or hazards to public health or safety by utilizing the principles of engineering to confine the refuse to the smallest practical volume, and covering it with a layer of earth at the conclusion of each day's operation." (as quoted in Eldredge Engineering, p. 33)

Sanitary landfills are engineered to minimize the nuisances to public health and safety when operated properly. Many methods of sanitary landfilling have been developed. Modern landfills often include liners and leachate collection systems. All solid wastes received at a site are spread and compacted in layers at the site. Wastes are covered daily with a layer of soil. The USEPA has stated that when properly located, designed, and operated, sanitary landfills protect human health and the environment (EPA/530-SW-88-011, 1988).

Current Requirements For Landfills in Illinois

The Resource Conservation and Recovery Act (RCRA) of 1976 empowered the USEPA to regulate the design and operation of landfills. In Illinois, there are two state agencies that regulate solid wastes, the Illinois Pollution Control Board (PCB) and the Illinois Environmental Protection Agency (IEPA). The IEPA has the power to enforce regulations and guidelines promulgated by the USEPA and the PCB with regard to siting, design and operation of a landfill. The PCB is the policy making body responsible for defining environmental control standards for disposal. IEPA is the implementation and enforcement agency for the PCB regulations.

In 1973 the PCB enacted the first regulations in Illinois regarding solid waste landfills. At that time, no distinction was made between the various types of waste that were disposed in landfills. The regulations have been amended since, and currently, landfills are regulated with regard to the type of waste disposed. As of September 1990, three types of landfills are permitted in Illinois: hazardous waste landfills, putrescible and chemical waste landfills and inert waste landfills. The standards applicable to each landfill are dependent on the age of the site and whether the site is new or existing.

Requirements for hazardous waste landfills in Illinois meet or exceed USEPA standards. States are required to promulgate rules at least as stringent as RCRA guidelines. Title 35 of the Illinois regulations provides the definition of hazardous waste and includes specific industrial by-products, pesticides and chemicals considered hazardous by USEPA. New hazardous waste landfills must install two or more liners, leachate collection systems, and run-on and run-off systems. Proper closure and post-closure care is required of all hazardous waste landfills. This includes maintenance of the cover, an operational leachate collection system and groundwater monitoring wells.

Since the advent of hazardous waste regulations, a number of different hazardous wastes have been banned from land disposal. Many of these restrictions have recently taken effect; therefore, the use of land disposal for hazardous waste should decline in the future.

The regulations governing putrescible/chemical waste landfills and inert waste landfills in Illinois are influenced by the restrictions on hazardous waste disposal. Part 811 of the regulations outlines the location standards for all nonhazardous waste landfills including consideration of the 100-year flood plain, habitats of endangered species and areas of historic or archaeological significance. Requirements are provided for the management of run-off from a landfill site. Compaction and daily-cover standards are provided as well as general operating standards. Closure and post-closure plans are also required.

The newest Illinois landfill regulations adopted in 1990, provide more stringent regulations for putrescible/chemical waste landfills and outline specific minimum standards to which existing sites must comply. The more comprehensive regulations primarily affect design, construction and groundwater monitoring aspects of landfills. New landfills must satisfy the requirements for siting, permitting, design, construction, quality assurance, landfill operations, monitoring, financial assurance and closure and post-closure care with a subset of these being applicable to existing sites. The location standards for new sites are specific with regard to the proximity to roads, dwellings and set-back zones. New putrescible/chemical waste landfills are required to have compacted earth liners and leachate drainage and collection systems. Landfill gas monitoring and groundwater monitoring systems are also required. Owners of existing sites who either cannot or choose not to comply with the minimum requirements such as more sophisticated groundwater monitoring were required to initiate closure by September 18, 1992. Landfills that have met specific portions of the new requirements may remain open for up to seven years (IEPA/LPC/91-59, 1991). In general, operators who wish to remain open for seven or more years must fully comply with the new regulations. Due to the stricter requirements, fifty-seven of the nonhazardous solid waste landfills active in 1991 notified IEPA of an earlier closure than reported remaining capacity would dictate.

For landfills accepting only inert wastes, a leachate test is necessary to determine how much, if any, contaminants exist. By definition, most inert wastes are construction and demolition-type debris like concrete, asphalt, rubble, general metals and masonry. The operator of an inert waste landfill may not accept wastes unless accompanied by documentation that the wastes are indeed inert (811.207), and must conduct random checking for verification.

Reporting Requirements for Illinois Landfills

Illinois landfills may be subject to a number of different reporting requirements depending upon the type of waste accepted. Landfills accepting hazardous waste are required to summarize annual activities and submit reports to IEPA. The IEPA publishes Hazardous Waste Annual Reports based on information submitted by generators and management facilities. The first such report was published in 1982. The reports list the volume of hazardous waste accepted at each permitted landfill.

As required by the Illinois Solid Waste Management Act of 1986, IEPA must publish an annual report projecting the available capacity for solid waste disposal in the state's sanitary landfills. The data used to compile these reports is submitted by landfill owners and operators. In addition to projecting available capacity, these reports are useful in estimating how much solid waste is disposed in Illinois' landfills. These reports do not specifically distinguish between special nonhazardous wastes and other types of waste considered to be nonhazardous. Nonhazardous special wastes, when disposed in putrescible/chemical waste landfills will be reflected in the reporting provisions of the Solid Waste Management Act.

Recent changes in IEPA reporting requirements require operators of facilities to report annual volumes of nonhazardous special wastes that are managed. This new report will provide information about quantities of these wastes disposed in landfills.

Number of Landfills in Illinois

As the number of environmental regulatory programs increased and waste disposal became the subject of increased public and political scrutiny, the number of landfills operating in the state declined dramatically.

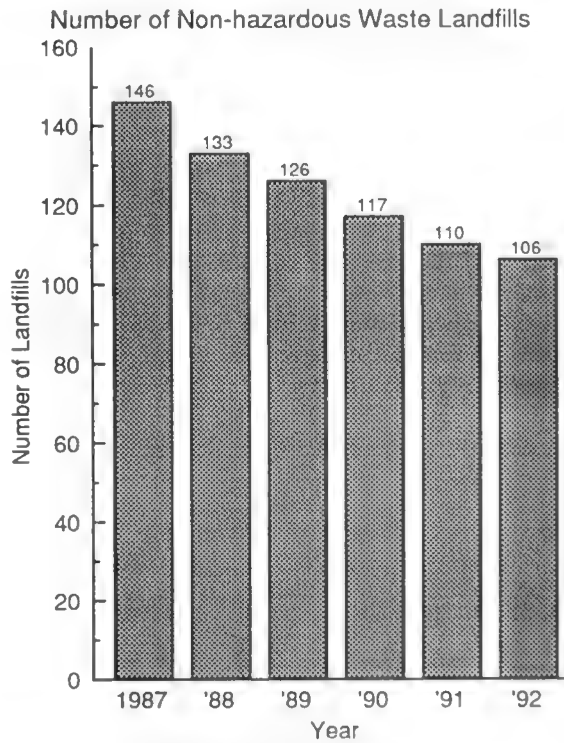
The development of new landfills has been well documented since regulation of landfills began about 1970, but identifying the precise number of sites prior to regulation is challenging. No central agency maintained records throughout the state and the level of precision varies where records were maintained.

A number of historical inventories have been conducted throughout Illinois using information from a number of sources to fill in the information gaps between pre-regulation and regulatory years. The most comprehensive of these efforts was automated and updated by ISGS for HWRIC between 1984 and 1988. The most recent report discussing findings of the inventory was published in 1990. This *Inventory of Landbased Disposal Sites* includes information from IEPA's regulatory files, public health and solid waste planning agencies and research conducted by historians in the Chicago metropolitan area. This inventory contains information about many types of land disposal sites both open and closed. The HWRIC inventory identified 3,079 sites in Illinois that at one time were classified as "landfills" including sites closed prior to regulation.

The IEPA maintains a Comprehensive Inventory of Special Waste Handlers which lists all types of facilities subject to regulation by the Division of Land Pollution Control. In 1990, this inventory listed 1,937 sites as landfills. In addition, 1,711 sites were classified as "Illegal Dumps", some of which are sites used for land disposal. The HWRIC and IEPA inventories are not directly comparable because of differences in definition and criteria for inclusion. It is reasonable to assume, however, that over 3,000 sites have been identified as operating or closed landfills.

During 1992, only 106 landfills in the state were actively accepting solid waste and were required to report remaining capacity to the IEPA. Most of these landfills are permitted to accept nonhazardous special waste and two have permitted commercial hazardous waste landfill sites at (or near) the same location. As a result of the changes in landfill regulations requiring minimum standards for monitoring and design, only 82 of these solid waste landfills continued to accept waste as of September 1992. It is anticipated that only 64 of these sites will remain active in 1993. In 1990 there were 17 sites permitted as non-regional pollution control facilities to accept nonhazardous special waste. These sites are used primarily for the disposal of wastes generated by industrial facilities at the site or one of its subsidiaries. In addition, there are several non-commercial hazardous waste landfills permitted to manage waste at the location of generation.

Figure 12.1 displays the number of landfills accepting solid waste that are subject to the Illinois fee (under provisions of the Solid Waste Management Act) from 1987 to 1992. The shrinking number of landfills in Illinois will potentially affect the state's capacity for solid waste disposal. The threat of higher disposal costs due to reduced capacity have pushed some municipalities and government officials to study solid waste planning more closely.



Source: Available Disposal Capacity for Solid Waste in Illinois, IEPA, January 1993.
Figure 12.1

Inert waste landfills have only recently been regulated as such, making statistics difficult to find. When the Solid Waste Management Act was enacted in 1986, the Illinois General Assembly recognized that landfills permitted to accept only demolition or construction debris or landscape waste pose less threat to the environment than other types of landfills. It was estimated at the time of the Act that over 300 landfills in Illinois accepted only these types of wastes. A recent estimate based on a 1990 IEPA Comprehensive Inventory databases listed 72 active sites permitted to accept demolition debris.

Landscape waste is now not permitted to be disposed in solid waste landfills. Composting sites throughout the state have been permitted to accept all types of yard waste.

Capacity For Landfill Disposal

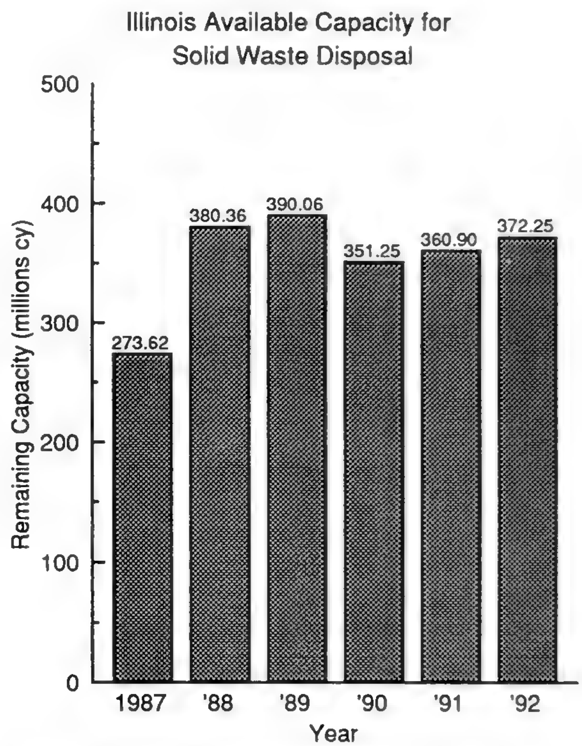
Despite the decline in the number of operating solid waste landfill sites, the state's reported landfill capacity for solid waste has increased in recent years (see Figure 12.2). These increases are due to improved reporting and the expansion and addition of several landfill facilities. The IEPA reported that, as of April 1, 1992, the state had 372.2 million cubic yards of remaining capacity for landfill disposal of solid waste. IEPA cautions, however, that the number of landfills submitting information in error remains high. The Agency has revised its solid waste capacity reporting requirements to include an engineer's certification of accuracy.
The fact that an increase in capacity for solid waste disposal is being accomplished with fewer landfill facilities is consistent with a nationwide trend to fewer but larger landfills. The average reported capacity per operating landfill in Illinois has increased since the first annual report on available disposal capacity (Table 12.1).

Table 12.1. Remaining Solid Waste Capacity Per Active Illinois Landfill

Year	Capacity Per Solid Waste Landfill (million cy)
1987	1.87
1988	2.86
1989	3.10
1990	3.00
1991	3.28
1992	3.51

Source: IEPA Available Capacity For Solid Waste In Illinois 1987-1992

Based on the data collected in the 1987 annual report, IEPA estimated that Illinois would have 5.3 years of disposal capacity remaining at that year's rate of generation. (IEPA/LPC/87-016, 1987) The imminent solid waste capacity shortage for Illinois suggested in that report has not occurred.



Source: Available Disposal Capacity for Solid Waste in Illinois, IEPA 1987-1992

Figure 12.2

The estimates of solid waste disposal provided by the provisions of the Solid Waste Management Act do not provide a complete account of all solid wastes disposed in the state. The wastes exempt from the fee and reporting requirements contribute a potentially large volume to landfill disposal in Illinois.

In 1986, the Superfund Amendments and Reauthorizations Act (SARA) required the State of Illinois to prepare a capacity assurance plan to demonstrate that there is adequate capacity for the destruction, treatment or secure disposal of all hazardous wastes expected to be generated during the next 20 years. The Capacity Assurance Plan (CAP) was completed by IEPA in September 1989 and using 1987 as the base year estimated capacity levels for the management of hazardous wastes for 2, 8 and 20 year intervals. The CAP was completed taking into account regulatory changes scheduled to take effect including the "land ban" prohibiting the disposal of many untreated hazardous wastes. For the base year of 1987 and for every projected year, (1989, 1995, 2009) landfill capacity for disposal of hazardous wastes surpassed the estimated demand. Not until 2009 do the remaining capacity figures suggest the threat of a hazardous waste capacity crisis (Table 12.2).

Table 12.2. Capacity Assurance Plan 1989
Remaining Capacity for Landfill Disposal of Hazardous Wastes

Year	Remaining Capacity (tons)
1987 (base year)	4,209,792
1989	4,535,822
1995	3,071,389
2009	3,721

Source: Capacity Assurance Plan: State of Illinois 1989

Location of Landfills in Illinois

Landfills are found throughout Illinois, with a higher concentration in the northeastern counties and in the counties of the St. Louis metropolitan area. A topic of some concern is the number of counties lacking landfill capacity. As reported in 1992, 39 counties have no active nonhazardous waste landfill. Localized capacity shortages may result causing price increases in affected areas.

Volumes of Waste Disposed By Landfilling

The best information that is collected about volumes of waste disposed in landfills is available from two reports. The annual *Available Disposal Capacity For Solid Waste in Illinois* summarizes the volumes of waste disposed and available capacity of nonhazardous waste landfills. Hazardous waste disposal is reported as part of Illinois' RCRA requirements in IEPA's *Annual Hazardous Waste Report.* While hazardous waste has generally received more attention, the amount of solid waste far exceeds the volume of hazardous waste disposed in Illinois' landfills. Solid waste in this instance includes municipal solid waste, industrial process waste and other waste types that are disposed in landfills subject to the provisions of the Solid Waste Management Act.

The amount of hazardous waste disposed in landfills in Illinois has varied from 194 thousand tons in 1985 to 359 tons in 1986. In 1990, 296 thousand tons were landfilled (Figure 12.3). In comparison, solid waste volumes disposed in landfills ranged between 14.14 million and 15.33 million tons (Figure 12.4). The solid waste disposal figures are assumed to include all wastes disposed at solid waste landfills with a portion being nonhazardous industrial wastes. Assuming there are no additional waste streams contributing to the volume of wastes disposed at landfills in Illinois, solid waste contributed 98 of total reported landfilled waste (Figure 12.5). This figure is not inclusive of all wastes that are potentially disposed in landfills. Construction and demolition debris wastes are exempt from solid waste reporting as are numerous other wastestreams that may have been disposed in landfills.

Types of Waste Disposed in Landfills

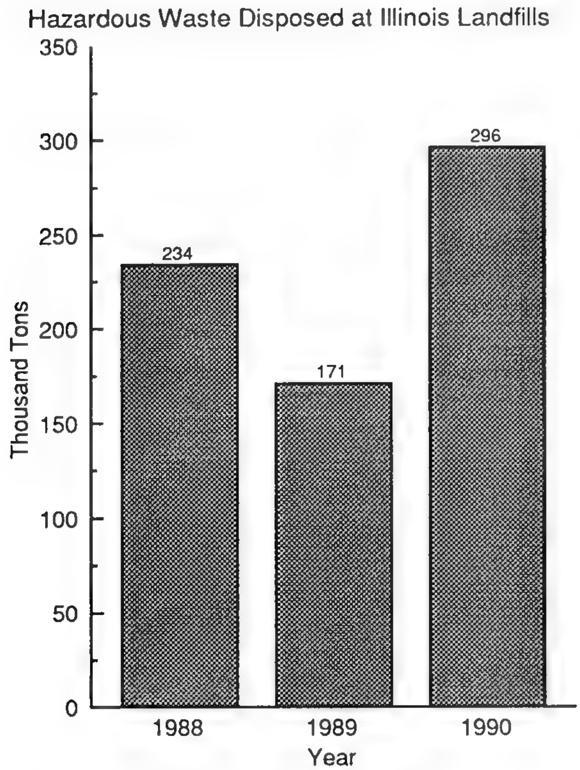
During the 1990 reporting year and for the 1989 Illinois Capacity Assurance Plan, the hazardous waste managed was classified by SARA waste types. The classification scheme groups waste by their physical and chemical properties making the resulting analysis easier to understand. During 1990, a limited number of types of hazardous waste were disposed in landfills: contaminated soil, inorganic sludges and solids with metals, halogenated solvents, inorganic sludges and solids not elsewhere classified, inorganic liquids with metals and mixed organics/inorganics sludges/solids. Table 12.3 lists the quantity of each of these waste types disposed in Illinois landfills in 1990.

Table 12.3. Hazardous Waste Disposed in Illinois Landfills 1990

Hazardous Waste Type	Tons Waste Landfilled
Contaminated Soil	26,131
Mixed Organic/Inorganic Sludges and Solids	443
Inorganic Sludges and Solids with Metals	81,577
Inorganic Sludges and Solids, NEC	2,361
Total Hazardous Waste Landfilled	110,512

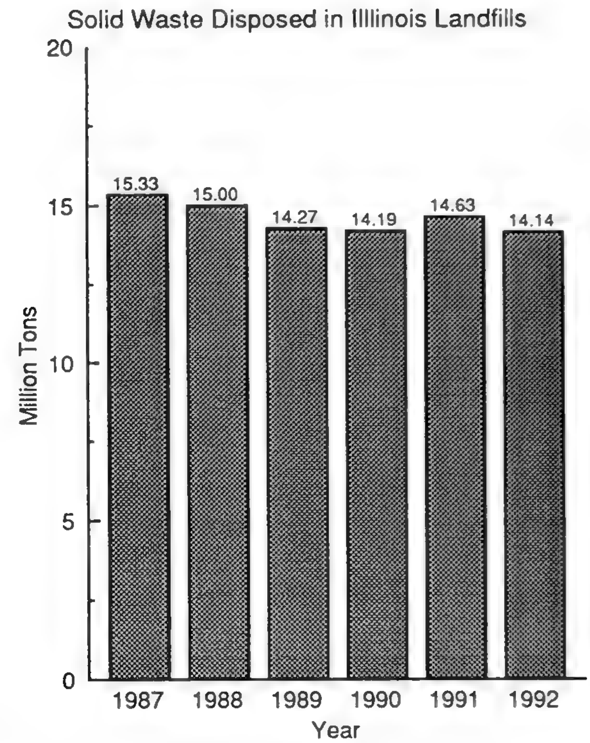
Source: Capacity Assurance Plan: State of Illinois 1989

Nonhazardous solid wastes disposed in landfills are generated at commercial and institutional operations and households. In addition, industrial wastes (that are not hazardous) are often managed in landfills. The USEPA has produced a series of reports characterizing the municipal solid waste stream. Paper and paper products represent the largest



Source: IEPA/LPC/92-052, IEPA, 1992.

Figure 12.3



Source: IEPA Available Disposal Capacity for Solid Waste in Illinois

Figure 12.4

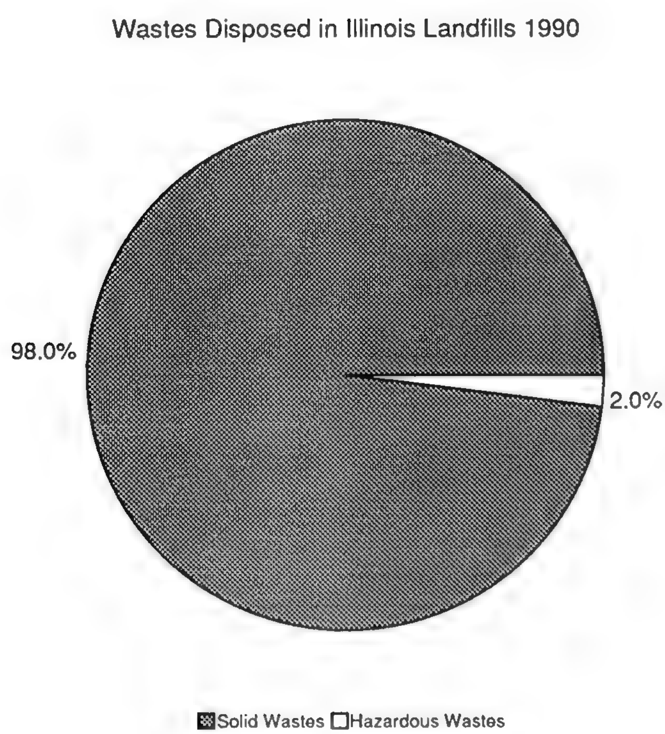


Figure 12.5

component of the solid waste stream that is disposed in landfills. In 1990, paper comprised 31.9% by volume of the wastes landfilled. Table 12.4 displays the relative composition of municipal solid waste (MSW) disposed in landfills based on USEPA's report (EPA-530-SW-92-019, 1992).

Table 12.4. Composition of MSW Disposed in US Landfills 1990 (percent of estimated cubic yards).

Waste Type	Percent Total Cubic Yards
Paper and Paperboard	31.9
Plastics	21.1
Yard Trimmings	9.8
Ferrous Metals	8.9
Rubber and Leather	6.1
Textiles	6.4
Wood	6.8
Food Wastes	3.2
Other	1.4
Aluminum	2.2
Glass	2.2

Source: Characterization of Municipal Solid Waste in the United States: 1992 Update, USEPA 530-R-92-019.

A 1993 report discussing construction and demolition (c/d) debris issues attempted to characterize that wastestream. It was reported that waste from residential construction typically consists of about 30% wood, 30% cardboard, 15% drywall, 10% metals and 15% consisting of plastic, foam, packaging and masonry. Although very little accurate information exists about c/d wastes, most studies assess c/d waste to be between 15-30% of total MSW. A portion of that waste is likely to be disposed in inert waste landfills in Illinois with the remaining being sent to putrescible/chemical waste sites.

Costs Associated with Landfill Disposal

Tipping fees, the fees associated with landfill disposal, are established by the landfill operator and are designed to cover operating and capital expenditures as well as other taxes and surcharges. As a result of more stringent regulations involving landfill disposal and decreased capacity, the costs of landfill disposal have risen steadily. A 1988 study conducted by the National Solid Waste Management Association identified an average national tipping fee of $27.93/ton (approx. $9.00/cy @ 3 cy/ton) (Eldredge Engineering, 1989). While there are several limitations to this study, including a disproportionate impact from the Northeast, the study is useful in identifying an overall trend. Most significantly, a doubling of fees occurred between 1986 and 1988.

Selected data are available for the Chicago metropolitan area (Cook, McHenry, Kane, Lake, DuPage, and Will counties) over a similar time period. Over that time, the average tipping fee in the Chicago area has remained lower than the national average. However, like the national statistics, an approximate doubling did occur between 1985 and 1987 (Table 12.5). During 1992, a statewide survey of tipping fees was conducted by Wehran Envirotech. For those same Chicago area counties surveyed in 1981-1989, the average tipping fee was $9.50/cy (approx. $28.50/ton @ 3cy/ton) showing a continued increase from the average tipping fees assessed in 1989.

Table 12.5. Chicago Metropolitan Area Average Tipping Fees 1981-1989

Year	$/Ton
1981	6.60
1983	8.01
1985	8.58
1987	16.70
1988	18.79
1989	19.03

Source: Tipping Fee Survey, Eldredge Engineering, Naperville, IL 1989.

Across Illinois, a 1992 tipping fee survey revealed that higher average fees are charged in the northern regions of the state and in the St. Louis metropolitan area. The lowest average tipping fees were found in the west central region. The overall state average fee was $7.42/cy with $3.00 reported to be the lowest rate and $17.67 the highest.

Landfill tipping fees in Illinois have not risen as dramatically as in some other states. Tipping fees have climbed as high as $100/ton in areas of the Northeast. In one respect, lower fees result in lower costs for disposal in this part of the country than in others. These same low prices also make Illinois an attractive location for the disposal of wastes from other states. Illinois may find landfill capacity depleting sooner than expected as more waste is brought in from other states. In addition, the new stricter landfill regulations have forced many Illinois sites to begin closure procedures sooner than their capacity would indicate. These two factors are expected to result in even higher landfill tipping fees in the future.

Potential Threats From Landfill Sites

While landfills are the most common disposal method in Illinois, their use is not without risk. Landfills have been associated with nuisances such as odors and litter, however, a more serious environmental concern are landfill gases and leachate. Both carbon dioxide and methane are produced as the result of the decomposition of organic materials disposed in landfills. Methane production, in particular, is a topic of concern because the gas becomes explosive at high concentrations. Leachate, a mixture of chemicals and water formed by rain, snow, surface water, groundwater or other sources of water entering or formed in a landfill (Lester, 1986), has the potential to contaminate surface and groundwater as the chemicals travel from the disposal site.

Environmental risks associated with landfill disposal are not a new discovery. Contamination of groundwater as a result of waste disposal was recognized as early as 1932 (Lisk, 1991). In 1986, USEPA conducted an investigation of landfills then on the Superfund National Priorities List (NPL) (EPA 530-SW-88-011, 1988). Twenty-two percent of the sites then listed or proposed for listing on the NPL were identified as municipal solid waste landfills. Many of the landfills on the NPL were old sites, but they do provide an indication of the potential problems associated with landfill disposal. The USEPA evaluated some of the impacts associated with landfill disposal in a report to Congress in 1988 entitled *Solid Waste Disposal in the United States, Volume 1 and Volume 2*. The focus of the study was disposal of Subtitle D (non-RCRA hazardous) waste, but the conclusions are applicable to most Illinois landfills. USEPA reported that "available data indicate that releases to ground water from some municipal solid waste landfills have degraded and may continue to degrade the environment" (EPA, 1988). The report did not conclude that specific releases were harming human health, but on the whole, the data indicated that some municipal solid waste landfills present potential risks to the environment and human health.

Illinois has more than 3,000 sites that at some point in their history have been used for land disposal of wastes. Disposal sites can be the source of considerable harm to susceptible ecosystems and water supplies. If not properly located, designed, and managed, these facilities can adversely affect resources near them. In the past, siting practices were less sensitive to the environment, and the disposal of both hazardous and nonhazardous wastes into municipal and private landfills was not well documented in Illinois.

For many years, hazardous waste has been deposited along with nonhazardous waste in the same facilities; so we can reasonably assume that many of these sites hold hazardous materials. Landfills are now regulated and primarily used to receive nonhazardous waste; however, an unknown quantity of hazardous household wastes is still legally disposed of. Disposal of industrially generated hazardous materials is strictly regulated by the Illinois Environmental Protection Agency (IEPA). Nonhazardous waste poses less of a threat to the environment than does waste defined as hazardous, although some materials with nonhazardous status have toxic characteristics that may lead to negative health or environmental effects.

Waste, whether hazardous or not, may produce contaminated leachate that contributes to environmental degradation at a landfill site. The type of waste collected at the landfill site determines the content of leachate generated, which may include dissolved organic compounds, bacteria, various minerals, heavy metals, and other toxic chemicals. Unless controlled, each of these contaminants can migrate a different distance, depending on the physical and chemical properties of the contaminants and the hydrogeological conditions around the site. Of primary concern is the potential for landfill leachate to contaminate shallow groundwater resources (aquifers) and aquatic ecosystems. The U.S. Environmental Protection Agency has documented environmental degradation due to land burial of municipal wastes from leachate migration (USEPA 1988). The effects ranged from polluted groundwater supply wells to fishkills in adjacent surface waterbodies.

Public and private water supplies, wetlands, deep water habitats (lakes), and public lands (recreation and wildlife areas) are among the areas or sites that would be susceptible to surface and groundwater degradation from a landfill found to be a source of contaminated leachate. In Illinois, for example, public, private, and industrial water wells have been abandoned when contaminants from nearby landfills were detected (Shuster 1976a, Shuster 1976b). Landfills located on floodplains can present a particular hazard to the quality of water downstream or in nearby wells because of the risk of flood waters inundating landfills and washing out the wastes. Unfortunately, past disposal siting practices have favored floodplains, marshlands, and abandoned gravel pits or quarries because they were considered remote or "waste lands" (EPA 1976).

Potential Impacts of Landfills in Illinois

Assessing the potential for landfill disposal to do harm is the first step toward prevention. The magnitude of the potential for contamination due to landfills in Illinois is discussed in this section within the framework of a simple proximity model, which simply refers to the nearness of the landfill to the vulnerable resource. The model is liberally adapted from two sources: (1) a USEPA, Florida State University, and U.S. Fish and Wildlife Service study that pertains to the proximity of landfills to wetlands (Lambou et al. 1988); and (2) a USEPA report (1988) to Congress on solid waste disposal in the United States, a study that evaluates health risks and environmental resource damage associated with groundwater contamination at municipal solid waste landfills (Subtitle D Risk Model). Both studies use one mile as an indicator of the area at risk from contamination due to leachate.

Using the computer-based Geographic Information System (GIS) and computerized location data for landfills and other sites of potential concern, researchers at the ISGS and HWRIC conducted a statewide screening to assess the proximity of landfills to environmentally vulnerable resources. Locations of the landfills and resources were extracted from statewide data sets on the Illinois GIS. The data sets have varying degrees of accuracy; each of which is addressed in the discussion of the database. By overlaying the location data for landfill sites and locations of vulnerable areas, we are able to address the following questions: How many landfills are located in areas of high potential for aquifer contamination? How many landfills are a potential threat to drinking water sources (public and private water wells)? How many landfills may adversely affect wetland and deep water habitats? How many landfills may potentially affect publicly owned lands?

The methodology used in this evaluation consists of a sequence of computerized spatial operations to create zones of landfill locations, overlay areas (polygon or point data) of specific resource information (public water wells or flood zones), and analyze the intersection and distribution of the resulting areas. For example, to find how many public water wells lie within one mile of a landfill, we surround each landfill location with a one mile buffer zone and overlay the data on the public water well point location data. Intersection of a landfill location buffer zone with a public water well location indicates that a conflict could occur. No consideration was given to the direction of leachate flow from the landfill and the physical and chemical properties of contaminants in the leachate. Analysis of constituent transport was beyond the scope of this study.

Landfill Locations

A statewide inventory of all known land-based disposal sites in Illinois was generated (Dixon et al. 1986) and updated (Mehnert et al. 1990) by the ISGS (Figure 12.6). Land-based disposal sites include landfills, land application sites, open dumps, surface impoundments, and any other sites where land is the final repository for waste (Mehnert et al. 1990). For the purposes of this analysis, only sites identified as containing landfills were analyzed. This database contains the locations of 3,079 landfills.

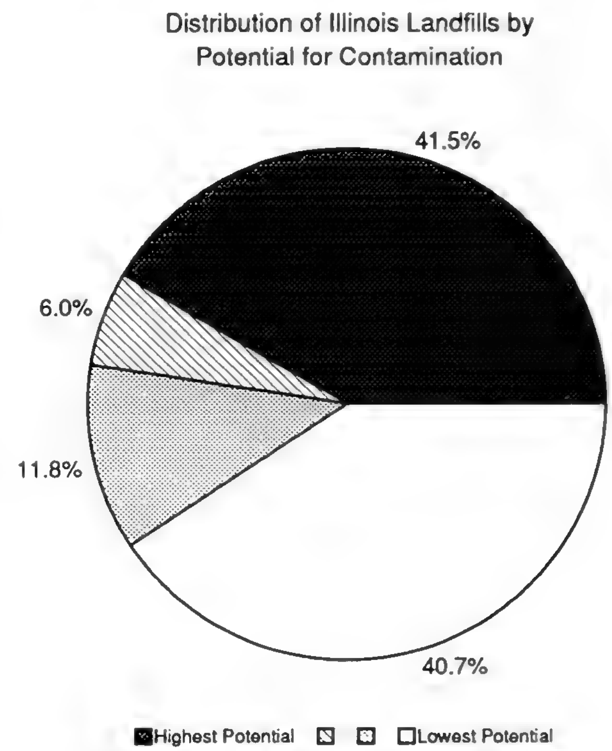
Accuracy of the computerized landfill location data is difficult to assess; however, an attempt was made to quantify the accuracy of the database. Champaign County was selected as the pilot study area for comparing inventory locations with field-verified locations. Section, township, and range locations were compared to aerial photos and/or field locations. While many landfills were located to within a quarter mile, all landfills that could be found were verified to be located within one mile of the database representation. Not all historical landfill locations could be determined with 100% accuracy; however, enough were found to support using the one mile buffered area as an estimate of the location site (i.e. it was assumed that the landfill was located somewhere within the one mile area). The results of this procedure, USEPA's one mile limitation (from their Sub-

Figure 12.6

title D Risk Model of 1988), and the USEPA joint study on landfill location proximity to wetlands (Lambou et al. 1988) all provided support for representing each landfill in the database as a one square mile area. This one mile region was applied to determine proximity of landfills to environmentally critical areas.

Potential for Contamination

The ISGS mapped the relative potential for contamination for aquifers statewide (Figure 12.8) by rating sequences of geologic materials for the susceptibility of its water-yielding materials to contamination from waste-disposal practices. The vertical sequences were rated by assessing the relative capacities of the earth materials to accept, transmit, restrict, or remove contaminants from waste effluents (Berg et al. 1984). It is impossible to assess the accuracy of this interpretive map, which is used principally to assist in regional, not site specific, assessments. It was used in this analysis to give an indication of how many existing landfills may be located in areas with high potential for shallow aquifer contamination. Figure 12.7 represents an estimate of the proportion of known Illinois landfill sites that fall into four categories of contamination potential. These four categories were summarized from classifications found in Berg et al. (1984).



Source: HWRIC Inventory of Landbased Disposal Sites, 1989; ISGS Aquifer Recharge Mapping

Figure 12.7

Public and Private Well Locations

The ISGS and Illinois State Water Survey (ISWS) each maintain extensive water well databases. The public water well database, developed and maintained at ISWS (Figure 12.9) contains 5,453 public wells, of which 3,496 are in use or held as emergency wells. The database is fairly accurate, as the locations of public water supply wells are carefully documented. The private well database at the ISGS (Figure 12.10) contains 146,691 wells and is a subset of a larger database containing more than 355,000 borings of all types drilled in Illinois. There is no reasonable way to assess the accuracy of the private water well database, but sample studies have shown that 75% of the wells used were located within a quarter mile of their actual locations.

For this study, we assumed that (1) the locations of public and private water supply wells are a good indication of the occurrence of groundwater

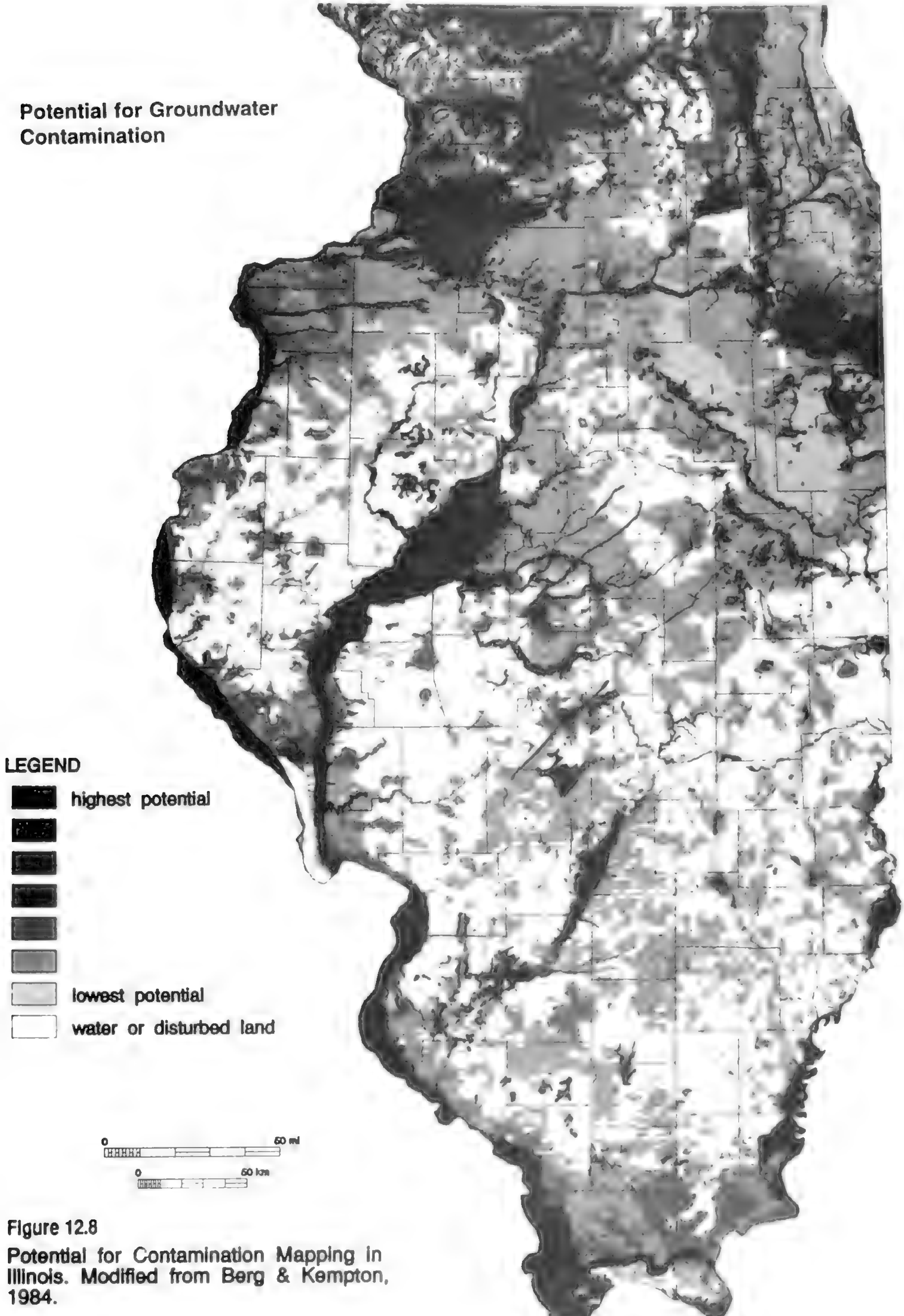


Figure 12.8
Potential for Contamination Mapping in Illinois. Modified from Berg & Kempton, 1984.

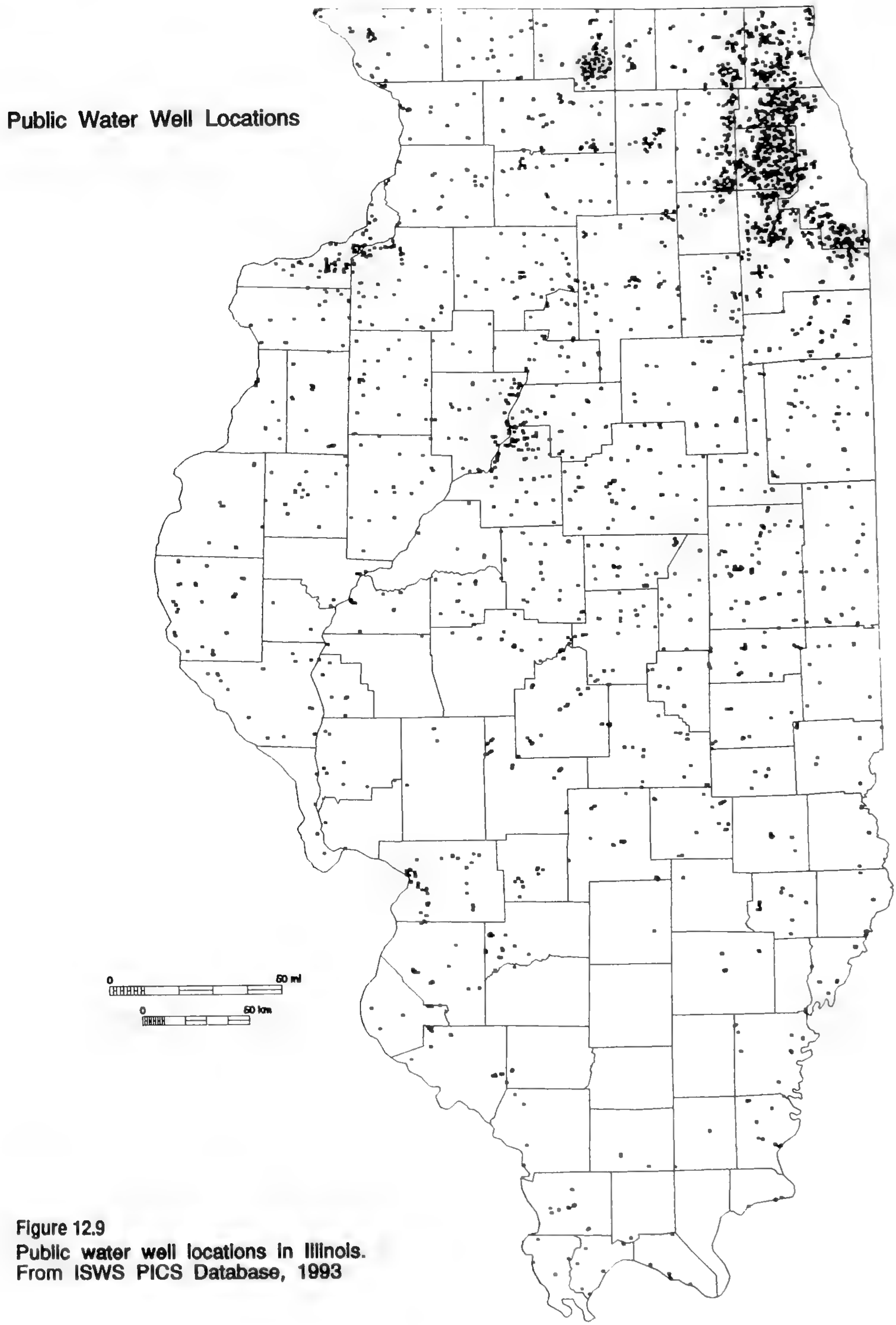


Figure 12.9
Public water well locations in Illinois.
From ISWS PICS Database, 1993

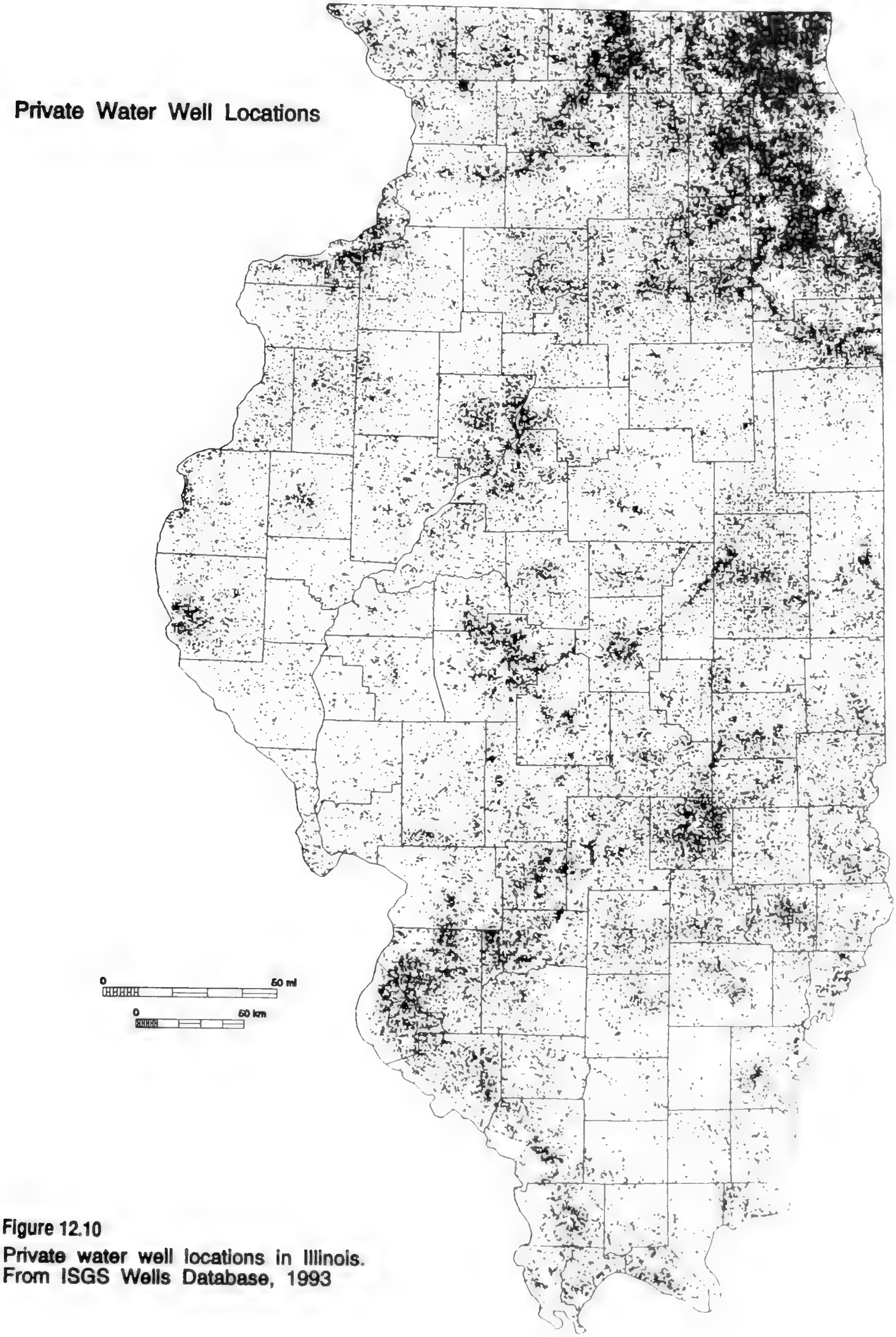


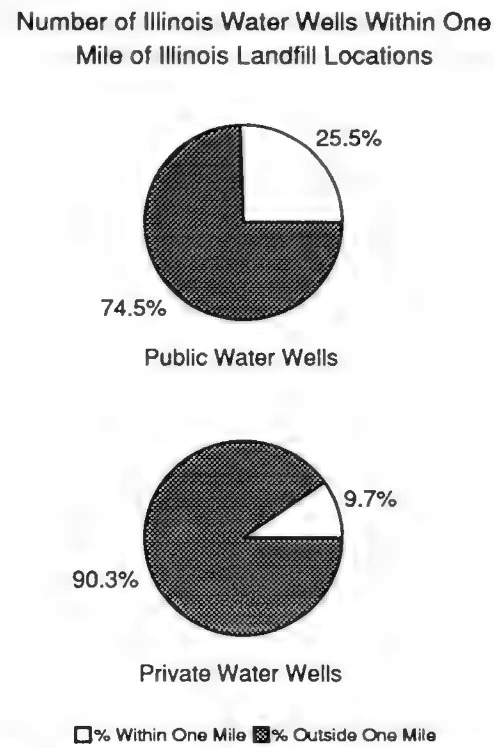
Figure 12.10

Private water well locations in Illinois. From ISGS Wells Database, 1993 resources, regardless of the depth of the well, and (2) the database represents the entire public and private water well universe. It was assumed for this analysis that public and private water wells within one mile of a landfill site may be susceptible to contamination. It was not within the scope of the study to determine the hydraulic gradient between every landfill and water well in the entire state; therefore some assumptions had to be made. In a worst case scenario, for example, all contaminants could move in every direction from the landfill. This is a conservative approach and any site specific study would reveal that this is not the case. For this statewide screening, however, the assumption was considered acceptable.

Analysis of the locations of private water wells revealed that the percentage of wells located within one mile is approximately 10% (Figure 12.11). Analysis of the locations of public water wells revealed that approximately 25% occurs within one mile of a known landfill (Figure 12.11). This finding is especially significant because many people can be impacted by the contamination and subsequent abandonment of a public water supply well. Considering that older municipal landfills were commonly sited near the urban area served and that public wells are drilled, whenever possible, close to the people using the water, it is not surprising to find landfills close to water wells. Improperly sited landfills, generally the older facilities, pose a risk to surface and groundwater supplies. The IEPA has documented cases of past contamination of public water wells by landfill sites (EPA/530/SW-517 1976, EPA/530/SW-514 1976). However, current monitoring regulations and siting criteria should minimize public water well contamination from landfills, regardless of proximity.

Public Lands

Public land data (Figure 12.12) came from the State Reserve System Units Database, which is part of the Illinois Geographic Information System (IGIS) Statewide 1:500,000-Scale Database. It contains State parks, nature preserves, game farms, recreational areas, and natural areas. The accuracy of this database is uncertain. Because many people use State lands and waterways for recreation, this analysis was included to assess the potential risk to these areas from migration of landfill leachates. For this study, we assumed that areas within one mile of a landfill may be susceptible to contamination. Nearly 5% of the total acreage of public lands falls within one mile of a known landfill (Figure 12.13).



Source: HWRIC Inventory of Landbased Disposal Sites, 1989; ISGS Coverages

Figure 12.11

Wetlands and Deep Water Habitats

Wetland and deep water habitat mapping covers areas that range from an occasionally wet meadow to a permanently flooded lake or river (Figure 12.14). Wetlands are transitional between aquatic and terrestrial systems; the water table is usually at or near the surface, or shallow water covers the surface (Cowardin et al. 1989). In Illinois, wetland habitats can be divided into 13 separate community types: scrub-shrub, swamp, bottomland forest, shallow marsh/wet meadows, deep marsh, open water wetlands, littoral lake, littoral shore, littoral emergent, perennial riverine, intermittent riverine, lacustrine deep water, and riverine deep water (Suloway et al. 1992).

Wetland locations in Illinois (digitized from 1:24,000-scale mapping) are fairly accurately represented in the wetland database, which comes from the National Wetlands Inventory of the U.S. Fish and Wildlife Service and is maintained and distributed by the Illinois Natural History Survey. The inventory for Illinois was conducted according to established national standards and not restricted by wetland size or type. For this analysis, however, type or size of the wetland was not considered.

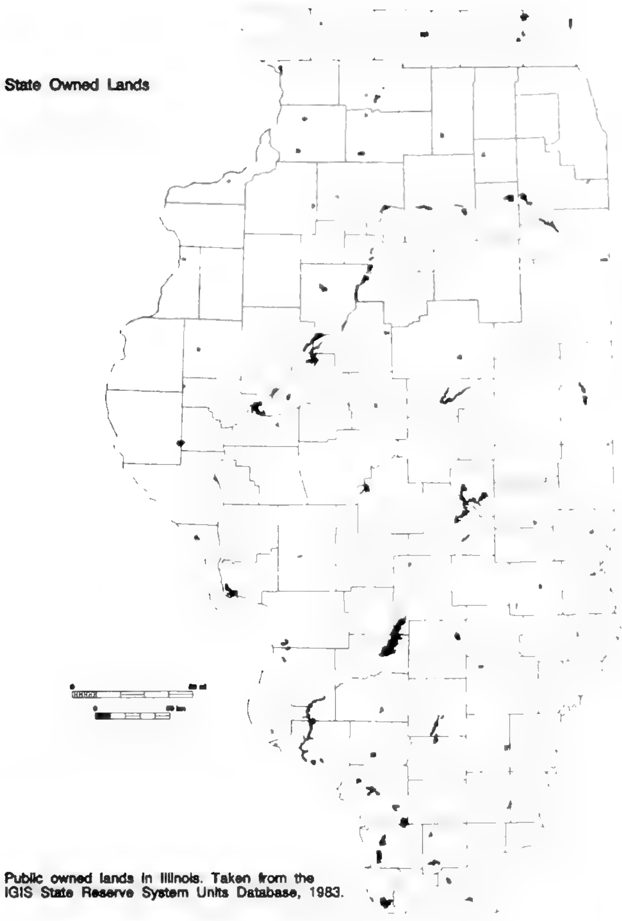
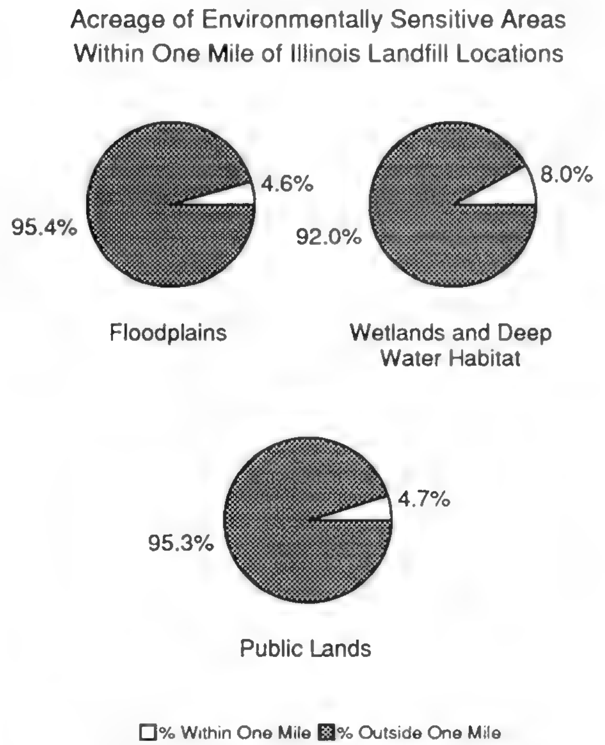


Figure 12.12



Source: HWRIC Inventory of Landbased Disposal Sites, 1989; ISGS Coverages

Figure 12.13

Wetlands currently cover less than 3% of Illinois. At the time of settlement, wetlands covered an estimated 8.2 million acres or 23% of the state. A policy of no net-loss of wetlands has been declared at the federal level because these ecosystems are so important to our planet (U.S. Fish and Wildlife Service 1990). They support a high degree of biological productivity due primarily to dynamic water levels. Wetlands regulate surface water flow and groundwater recharge and also act as filters, cleaning water and trapping sediment (see wetlands section of the Critical Trends Technical Report, *Volume 3: Ecological Resources*). Protecting wetland areas from biological, chemical, and physical degradation that may occur as a result of leaking landfills is important. Any unnatural decline in the productivity and diversity of wetlands may have an adverse impact on our environment.

Estimates of the number of designated wetlands within one mile of a known landfill were determined in this analysis. Of the total acreage of wetlands and deep water habitats, 8% is within one mile of a known landfill (Figure 12.13). This represents more than 100,000 acres of wetlands and deep water habitats potentially at risk if contaminants migrate from associated landfills.

Flood Hazard Areas

A floodplain is the relatively flat area bordering a river that is inundated when the river overflows its banks (Costa and Baker 1981). Landfills on floodplains may pose risks to the environment if wastes wash out of the facility during episodes of high water. In the past, there were no restrictions on siting land disposal facilities on floodplains in Illinois. The Illinois Pollution Control Board now mandates (1) that a landfill must be designed, constructed, and operated to prevent washout of waste from a landfill during flooding, and (2) that the flow and storage capacities of the floodplain not be reduced by a landfill. Maps from the Federal Emergency Management Agency, the National Flood

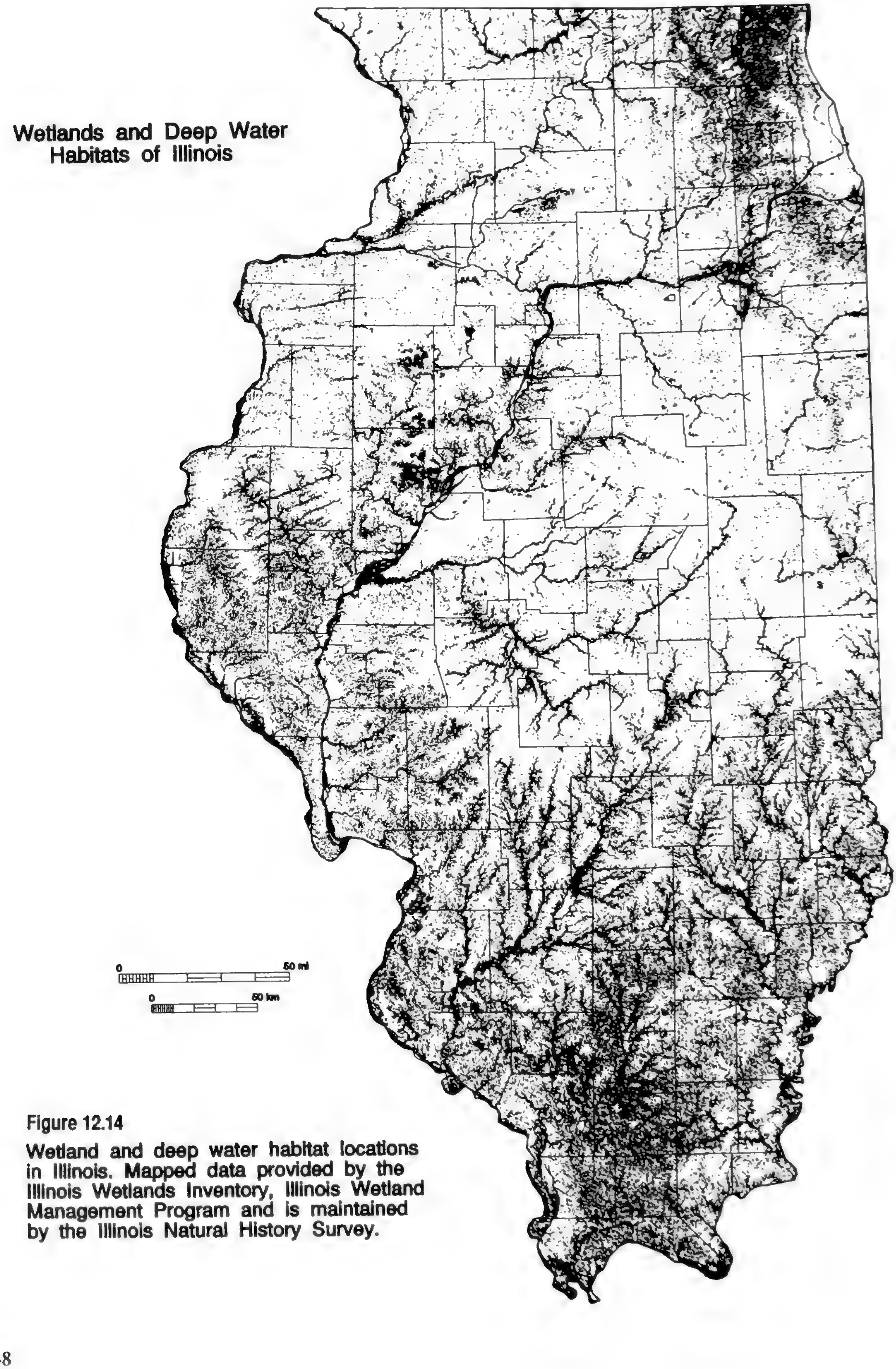


Figure 12.14

Wetland and deep water habitat locations in Illinois. Mapped data provided by the Illinois Wetlands Inventory, Illinois Wetland Management Program and is maintained by the Illinois Natural History Survey.

Insurance Program, and Flood Hazard Boundary Maps were compiled by the Illinois State Water Survey to delineate flood hazard areas throughout Illinois (Figure 12.15). This database was digitized from mapping at a scale of 1:12,000 and 1:24,000, which should be fairly accurate. Analysis of this data reveals approximately 17,000 acres, or nearly 5% of the acreage designated as flood hazard areas (up to 500-year flood zones in unincorporated areas), fall within one mile of a known landfill (Figure 12.13).

Flood Hazard Areas

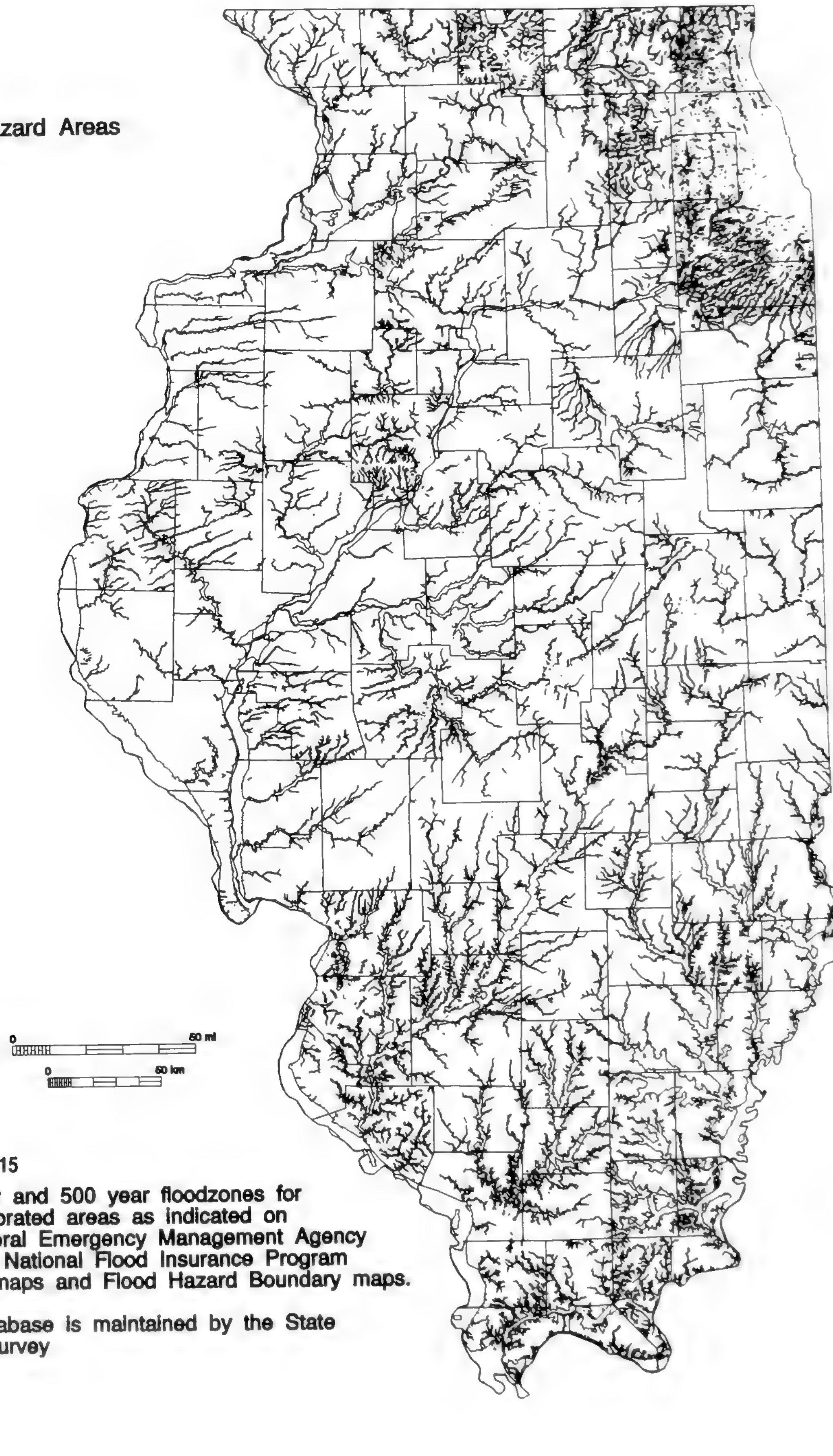


Figure 12.15

100 year and 500 year floodzones for unincorporated areas as indicated on the Federal Emergency Management Agency (FEMA), National Flood Insurance Program (FIRM) maps and Flood Hazard Boundary maps.

This database is maintained by the State Water Survey

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RECYCLING

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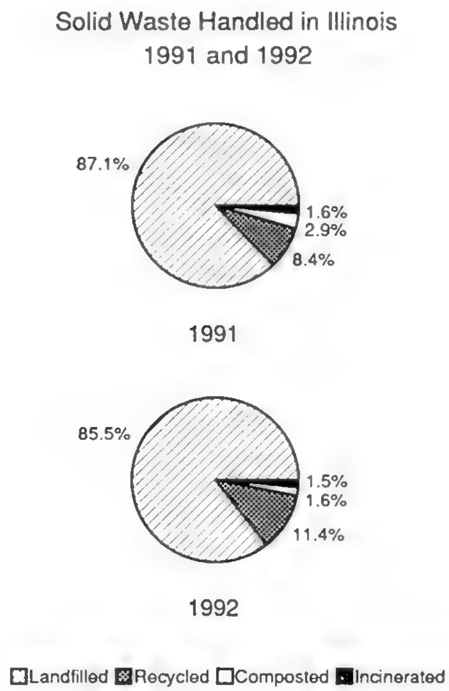
Recycling has become an important waste management alternative as costs for disposal increase, capacity for disposal declines and public pressure forces government and industry to pursue "environmentally-friendly" means for managing wastes. Some Illinois companies and communities have been active in recycling activities since the 1970's but a higher level of interest developed in the late 1980's. Recycling activities help reduce the amount of waste requiring disposal in the state, extending the available capacity for waste disposal.

Recycling plays and important part in the solid waste management strategy of the state and individual communities. The Solid Waste Management Act of 1986 set the standard Illinois communities must attain in their recycling efforts. Passage of this act spurred on development of community recycling programs and contributed to increasing amounts of solid waste being recycled. IEPA estimated that recycling accounted for 11.4% of solid waste managed in the state in 1992. Figure 13.1 shows the relative importance of recycling among the other methods used for solid waste management: landfilling, composting and incineration.

In 1992 there were approximately 476 recycling facilities located in the state for the collection of solid wastes. These facilities may collect paper (newspapers, magazines, corrugated cardboard boxes, computer paper, office paper), glass, plastics, metals (aluminum, steel food cans, bi-metal cans, industrial scrap metals) and miscellaneous products like used motor oil and lead-acid batteries. Facilities are located in at least 57 of the state's 102 counties.

IEPA has collected information about solid waste recycling since 1989 in conjunction with the publication of the Available Disposal Capacity for Solid Waste Reports. Each year, a survey was sent to the state's recycling centers to collect information about nine different categories of recyclables: paper, metals, glass, aluminum, oil, white goods, plastic, batteries and tires. The information provided by recyclers was done so on a voluntary basis. IEPA

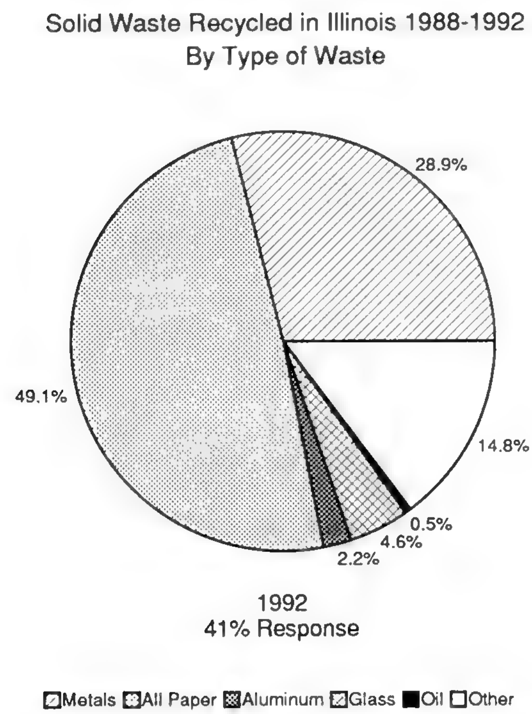


Source: IEPA Available Capacity for Solid Waste in Illinois, 1992
Figure 13.1

reported a response rate of 41% for the 1992 reporting year with 196 facilities completing the survey. These 196 facilities reported collecting 1,182,224 tons of materials between April 1, 1991 and March 31, 1992. Actual statewide volumes of recycled materials are potentially larger considering 59% of the recycling facilities did not respond to the survey.

While the IEPA survey does not provide a complete picture of recycling activities in Illinois, the results can be used to demonstrate the composition of materials collected for recycling. In 1992, paper comprised the largest portion of recycled materials with 49.1% of the reported volume. Metals comprised 28.9% of the reported volume. Figure 13.2 displays the relative composition of recycled materials for 1992. The percentage of metals recycled has decreased since 1989, while the volumes of paper and "other" materials increased. The "other" category is comprised of white goods, batteries, plastic, tires and other items. White goods comprise the largest portion of that category with 84.9% of reported tons (figure 13.3).

The source of these recycled materials is difficult to



Source: IEPA/LPC/92-219

Figure 13.2

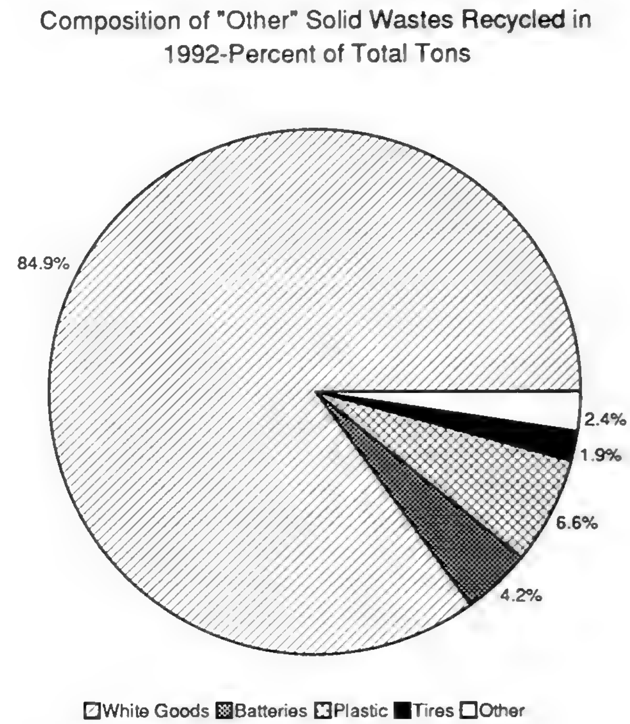


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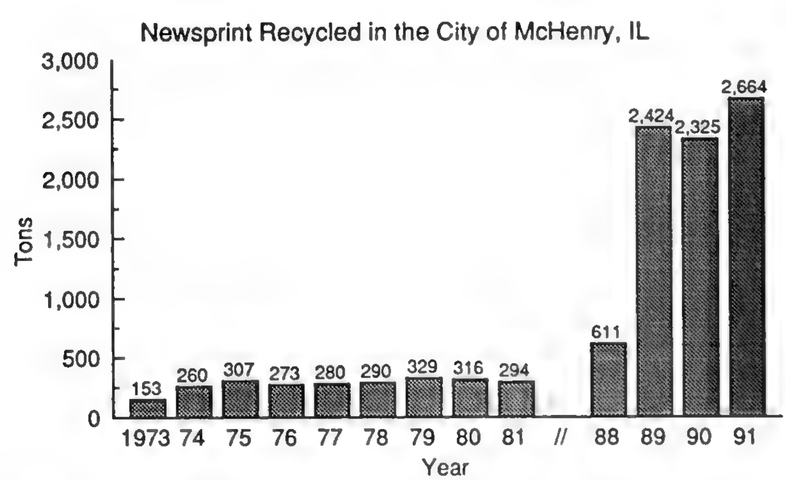
Figure 13.3



Source: McHenry Co. Defenders and McHenry Co. Department of Solid Waste Management

Figure 13.4

Table 13.1. McHenry County Municipal Solid Waste Recycling Statistics
Material (volumes given in tons)

Material	1988	1989	1990	1991
Glass	573	1,067	1,917	2,286
Aluminum	671	832	699	691
Tin	64	51	293	459
Paper	4,856	8,376	10,248	12,172
Plastic		20	126	266
Battery	300	350	242	571

Source: McHenry County Defenders and McHenry County Department of Solid Waste Management.

identify. Residential, commercial and industrial generators each provide materials to these facilities. Solid waste planning projects have provided estimates of the recycling rates for different waste types in selected counties. These studies were conducted between 1988 and 1992 and on average reported a recycling rate of 11.6% of generated waste.

Recycling programs in McHenry and Champaign counties are among the most successful in the state. The programs were initiated by the non-profit McHenry County Defenders and Community Recycling Center and gradually evolved to include significant local government participation. Figure 13.4 shows the tons of newsprint collected in the city of McHenry. Early volunteer efforts averaged almost 300 tons per year by 1981. Increased public interest and government participation increased that amount to 2664 tons by 1991. McHenry County recycling statistics for 1988-1991 show a significant increase in volume from 6,464 tons to 16,445 tons of material collected for recycling (Table 13.1). Data from Champaign County show that the volumes of recyclable materials marketed increased from 222 tons in 1978 to 5,538 tons in 1992 (Table 13.2). Newspaper and glass have consistently been collected in high volumes. Data from 1985-1992 show that substantial progress has been made in collections of cardboard and high grade paper.

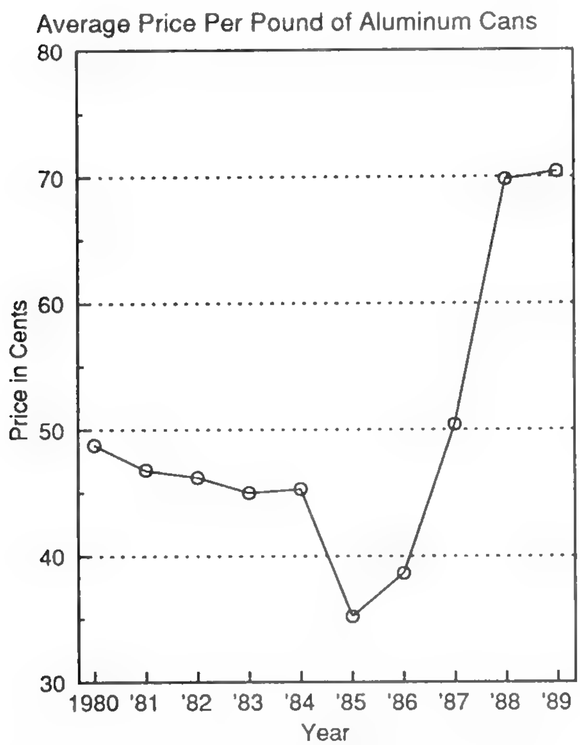
Many industrial facilities are finding that recycling can cut their disposal costs as well as help the environment. For example, the Viscase plant in Bedford Park recycles over 50,000 pounds of office paper per year that it would otherwise pay to landfill.

The success or failure of any recycling program is influenced by the volumes of materials collected and changes in market price. Trends in market price vary with type of material and geographic location and vary greatly from year to year. Between 1980 and 1989, the nationwide average price per pound of aluminum cans increased from about 50 cents to 70 cents (figure 13.5) but dropped to 35 cents in 1985. During that same time period, prices for old newspapers fluctuated substantially. Figure 13.6 demonstrates these fluctuations and reveals significant regional differences in market price. A similar regional trend occurred in pricing for corrugated containers (figure 13.7) and again prices are found to fluctuate considerably. Given these price variations, it is difficult for recycling facilities to achieve a steady cash flow for materials marketed.

Used oil presents some unique problems and opportunities for the state and local communities to manage. Above a certain volume, used oils are considered a special waste requiring manifesting and annual reporting. Oil wastes have the potential to contaminate water resources if not managed properly. Used oil also has a large potential for re-refining and energy recovery. Used oil recycling has become a more popular means of re-using waste oils and keeping them from improper disposal methods.

It was estimated by ENR that 69.9 million gallons of used oil was generated in Illinois during 1989. Of this volume, 10.2 million gallons was generated by do-it-yourself (DIY) auto maintenance, 34.2 from non-DIY auto maintenance and 25.5 million gallons from industrial sources. A percentage of these waste oils are burned for energy recovery or blended with other fuels to create a source of energy.

In addition to oil recycling at industrial facilities, a variety of oil recycling programs exist in the state for residential or other commercial sources. For example, Naperville operates drop-off centers and collects used oils curbside with an approximate collection volume of 16,800 gal/year. In addition, some service stations in Naperville area accept used oils. The city of Rockford operates a permanent used oil collection facility. The Growmark Corporation, FS federated cooperative located in Bloomington had been the sponsor of 10 collection days in 1990. The Livingston County cooperative, Pontiac, IL, collected 3,000 and 5,000 gallons during two collection days.



Source: Aluminum Association; Can Manufacturers Institute; Resource Recycling; Nov. 1989

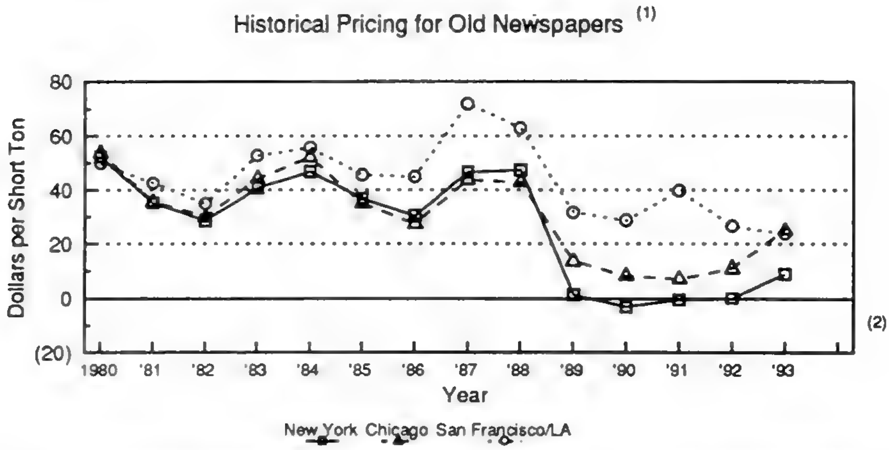
Figure 13.5

Table 13.2. Volume (tons) of Recyclable Materials Collected and Marketed from the Champaign Area - 1978 through 1992

Material	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Glass	91	198	252	361	341	341	495	505	573	881	1056	1133	1151	1223	1133
Newspaper	109	250	425	454	473	623	1039	1123	1615	2160	2588	2767	2982	2788	2473
Cardboard	14	80	133	117	71	75	231	250	138	165	271	578	711	818	2008
High Grade	0	27	47	32	39	15	26	30	351	350	593	699	1023	1040	1141
Aluminum	1	3	48	81	113	152	259	261	247	263	354	323	354	437	440
Bimetal	6	17	22	31	31	52	97	90	84	109	163	121	39	41	20
Tin	0	16	23	40	35	23	62	40	50	94	127	158	222	173	83
Scrap Metal	0	0	8	11	7	4	12	5	19	29	9	7	11	18	1
Mixed Paper[1]	0	0	0	0	0	7	19	36	112	104	113	110	157	63	
Plastic	0	0	0	0	0	0	8	0	0	0	19	61	71	75	92
Oil (gal)[2]	300	546	9931	25242	24864	22402	27344	8996	3230	4269					
Oil (ton)	1	2	37	95	93	84	103	34	41	114	51	59	79	7	
Total Tons[3]	222	593	995	1222	1203	1376	2351	2374	3230	4269	5344	6016	6800	6080	5538

[1] Volume of mixed paper recycled were not available for 1978 - 1982.
[2] Oil: 1 gallon = 7.5 pounds.
[3] Annual totals have been adjusted to include all oil volumes reported in tons.

Source: Community Recycling Center, Champaign, IL.

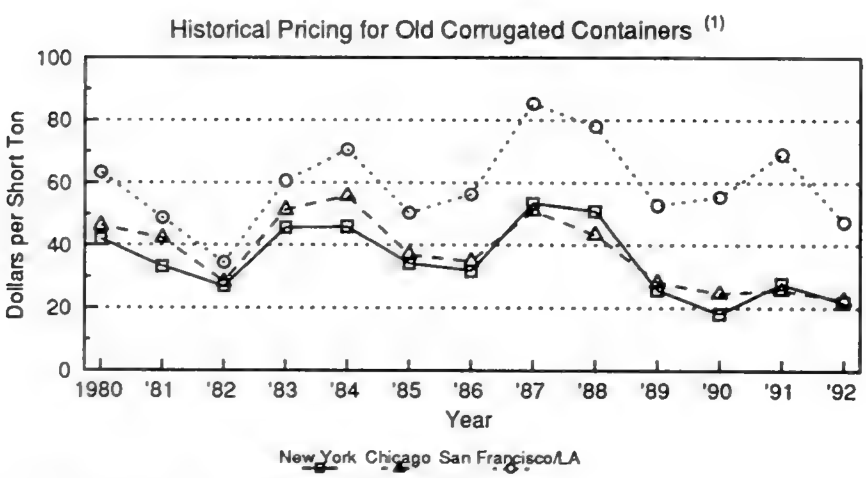


(1) Prices reflect mill purchase prices, f.o.b. seller's dock, for a No. 6 news as defined by the current Paper Stock Institute of America Standards & Practices Circular.

(2) Prices through May only.

Source: Resource Recycling July 1992 and July 1993

Figure 13.6



(1) Prices reflect mill purchase prices, f.o.b. seller's dock, for No.11 corrugated containers, as defined by the current Paper Stock Institute of America Standards & Practices Circular.

Source: Resource Recycling March 1993. As corrected.

Figure 13.7

SOURCES

Available Disposal Capacity for Solid Waste in Illinois Fifth Annual Report; Illinois EPA Division of Land Pollution Control; IEPA/LPC/91-59; October 1991.

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SURFACE IMPOUNDMENTS

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Surface impoundments are used for the retention, treatment and/or disposal of both hazardous and nonhazardous liquid waste. Whether in natural topographic depressions, artificial excavations, or dike arrangements, surface impoundments are used primarily for storage, treatment, or disposal of fluid wastes. They may be constructed above, below, or partially in the ground, and may have a permeable bottom and/or sides. Impoundments are wider than they are deep, ranging in area from a few tenths of an acre to hundreds of acres (adapted from USEPA 1978).

Surface impoundments can be used to dispose of all kinds of wastes, ranging from relatively innocuous substances to highly toxic materials. The terms pits, ponds, and lagoons are used interchangeably with surface impoundments.

The number of currently active or abandoned impoundments in Illinois is unknown. In 1980, the Illinois Environmental Protection Agency (IEPA) conducted an inventory and assessment of surface impoundments in Illinois and found approximately 7,450 active or abandoned impoundments (Figure 14.1). The inventory was based on information in files of permitting agencies; no field verification or count was made (Piskin et al. 1980).

Five categories of impoundments were inventoried: oil and gas (3,050), municipal (2,125), manufacturing and utility (965), agricultural (270), and mining (258). The IEPA suggests that more impoundments are associated with agriculture than were documented in their files; the numbers generated in their study should be considered conservative.

Oil and Gas Exploration and Extraction Waste

Impoundments associated with the oil and gas industry are used for disposal of exploration and production waste. In the past, most were used for brine disposal. Exploration and production wastes include produced water (brine), drilling fluids, and associated wastes. If mismanaged, these wastes can pose risks to soil, surface water, and groundwater (USEPA 1978). The oil and gas industry was once the largest user of surface impoundments for disposal in Illinois, but this practice has been curtailed since 1980. The Illinois Department of Mines and Minerals (IDMM) estimates that approximately 500 to 700 pits remain in the state today. Regulations still allow impoundments to be used for the disposal of produced water (brine) (Piskin et al 1980, IDMM 1993); but IDMM has proposed regulations (Illinois Admin. Code 62, Ch. 1, Sec. 24, Subpart H) that will prohibit evaporation pits altogether. All existing pits must be closed within 6 months of the adoption of these rules (IDMM, personal communication 1993). Current oil and gas regulations set impoundment use criteria to protect soil and usable water from contamination. Oil and gas pits are now used primarily for temporary storage of wastes. Impoundments utilized in exploration and production processes include temporary pits for drilling purposes, burn pits, completion pits, separator ponds, and plugging pits (IDMM 1993).

Municipal Domestic Sewage Waste

For the collection, treatment, and disposal of domestic sewage wastes, municipalities and associated entities make use of many impoundment sites in Illinois. Treatment plants have handling capacities that range from a few tens of thousands of gallons of waste per day to those handling several hundred million gallons per day. Impoundments are used in sewage treatment processes for temporary storage, settling, or disposal of liquid waste by percolation and evaporation. Secondary treatment effluent is processed in impoundments containing chemicals to settle suspended solids and activated sludge to help stabilize the waste. Sewage sludge is put into drying impoundments, then disposed of in landfills or through land spreading (USEPA 1978, Piskin et al. 1980). These operations must be permitted by the IEPA and are required to submit quarterly reports to the County Department of Public Health. Sites are frequently inspected by regulatory agencies.

Mining and Milling Waste

Mining impoundments are used to concentrate minerals and to dispose of processing slurries associated with both coal and noncoal mineral extraction. Surface or open-pit mines, which are sometimes excavated to depths below the water table, may require the water to be collected in settling ponds. Similarly, some underground mines must be pumped free of groundwater. The groundwater may be acidic

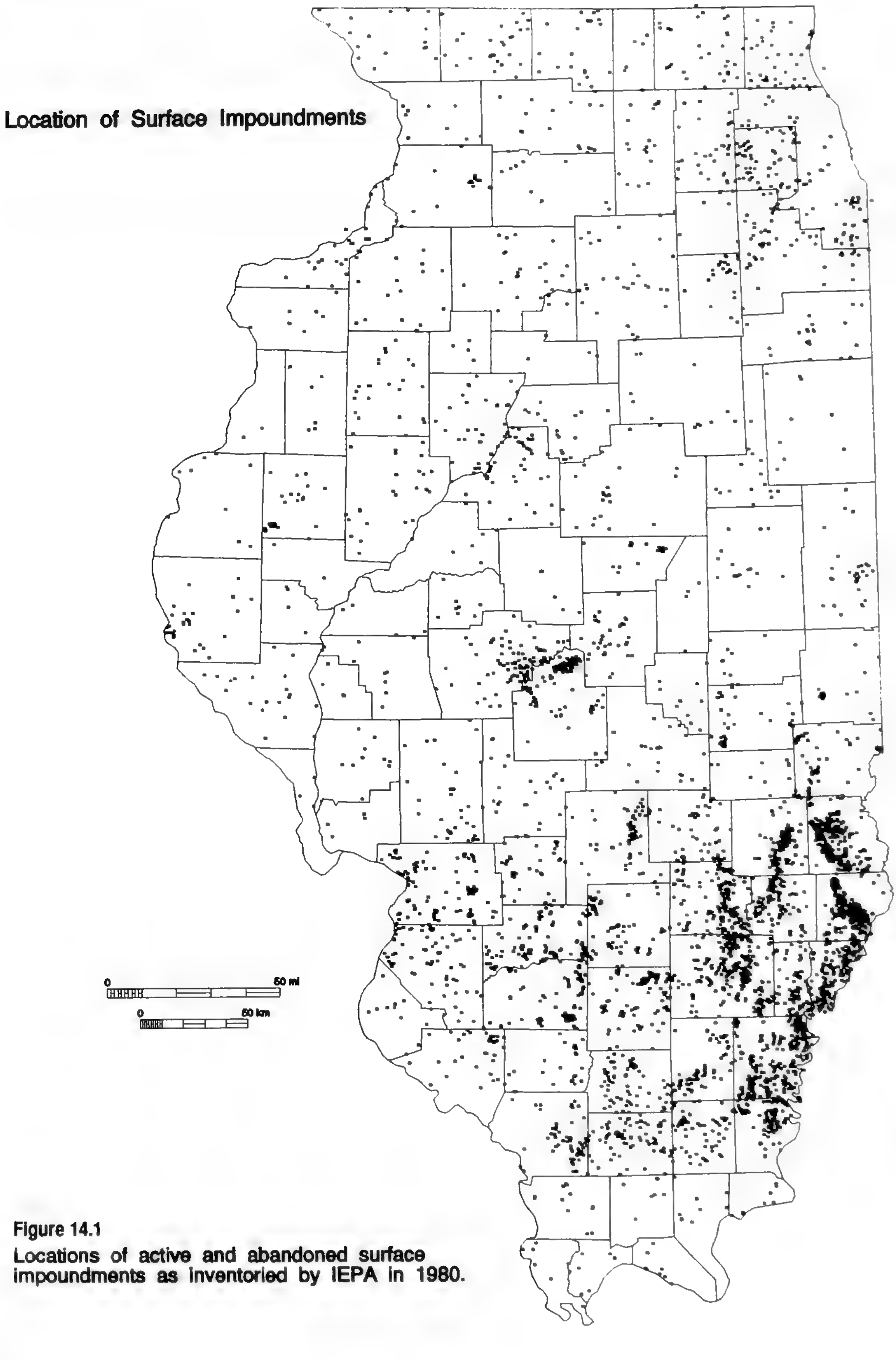

Figure 14.1
Locations of active and abandoned surface impoundments as inventoried by IEPA in 1980.

in nature and is generally deposited in settling ponds. Such impoundments generally exist throughout the life of the mine.

Mineral processing of sand and gravel, microcrystalline silica (tripoli), ganister, novaculite, silica sand, stone, clay and shale, barite, and fluorspar may require impoundments for washing and sorting. Coal mines in Illinois utilize slurry impoundments for the coal preparation process. Tailings (fine grained wastes) from mineral extraction and milling are transported to impoundments for dewatering and disposal. Mineral ores, such as fluorspar, generally consist of the principal mineral, some waste rock, and associated minerals. In the process of extracting the valuable minerals, ores are crushed to a fine size and concentrated by gravity, flotation, or chemical leaching. Impoundments are commonly used for the eventual disposal of the remaining byproducts. Seepage of fluids from these impoundments and tailings ponds has been a concern, especially if the byproducts become concentrated contaminants (USEPA 1978, Piskin et al. 1980, OTA 1992).

Industrial Waste

Industrial impoundments are used to treat, store, and process waste fluids and sludge from manufacturing and service industries (Piskin et al. 1980). Some industries treat and discharge wastes into ponds for storage, evaporation, recycling, or infiltration. Stabilization ponds are one of the major waste-treatment systems used by industries because the costs are low. As industrial waste streams can vary in composition and rates of flow, storage ponds are frequently used to blend the wastes and stabilize the flow for subsequent treatment. Nonhazardous industrial sludges are permanently held in impoundments by many industries in Illinois (IEPA 1978)). In other cases, they are stored temporarily in impoundments before being removed to landfills or spread on land used for crops (not destined for human consumption) (USEPA 1978, Piskin et al. 1980). Cooling water from power plants is commonly discharged into lagoons for treatment and retention. Settling ponds are used to store ash residues from coal-burning utilities. Industrial waste that is considered hazardous is placed in impoundments that must meet strict construction and monitoring criteria.

Agricultural Waste

Agricultural waste impoundments are generally associated with feed lot operations and principally used for storage. Several types are used, including debris basins (to collect runoff from animal pens); aerated lagoons and disposal lagoons (constructed to biologically decompose organic wastes); holding ponds (constructed to store the liquid part of animal waste runoff); and storage lagoons (constructed for the temporary or permanent storage of manure) (USEPA 1978). Most of these impoundments are unlined.

THE ENVIRONMENTAL RISKS OF WASTE DISPOSAL

Primary concerns associated with waste disposal into surface impoundments are the potential to degrade or contaminate surface and underground sources of drinking water, render soils unsuitable for agricultural use, and pollute the air with dust from dried-up impoundment surfaces.

Stored wastes may percolate through unlined or improperly lined impoundments into underground sources of drinking water. The groundwater contamination potential of an unlined surface impoundment depends on soil permeability, geochemical characteristics of the soils, depth to the water table, rates of precipitation and evaporation, nature and volume of the waste, and chemical composition, especially of waste containing potentially hazardous materials. Few older impoundments in Illinois are lined. Because the soils beneath and adjacent to many of them may be permeable, slow seepage of contaminated fluids from these impoundments represents a potential threat to surface and groundwater quality. In Illinois, an estimated 27% of the surface impoundments inventoried in 1980 are located in areas where near-surface geological conditions are highly likely to allow leachate to infiltrate the subsurface. A more comprehensive inventory of surface impoundments, including field-checking of locations, is needed to estimate the potential risks to usable sources of drinking water (USEPA 1978, Piskin et al. 1980).

Soils as well as surface and groundwater can be contaminated if impoundments, lined or unlined, are allowed to overflow. Mismanagement of influent can be as much a problem as heavy precipitation and flooding. Excessive precipitation can also cause breaks in the sides or dikes around an impoundment, so waste comes into contact with the soil (USEPA 1978, Piskin et al. 1980). When certain kinds of waste contact the soil, colloidal particles are disaggregated, destroying the soil structure. Soils cannot support plant growth and are easily eroded when the structure is compromised (United States Salinity Laboratory 1969).

When slurry ponds dry up, wind erodes materials and carries the particles to nearby areas. Although less of a concern than groundwater pollution, air pollution has been documented in association with coal mining impoundments in Illinois (Nawrot et al. 1982, Bradford 1987).

CURRENT STATUS AND THE ENVIRONMENTAL IMPLICATIONS

Locations and Use

Many changes have occurred in the locations and uses of impoundments since the 1980 inventory. There is no current, readily available information as to how many surface impoundments exist in Illinois; how they are constructed (lined or unlined); what type and amount of waste they contain (influent /effluent analysis); whether they are used for treatment, storage, or disposal; and what potential risks are associated with treatment, storage or disposal. The IEPA and IDMM gather some of this information as part of the permitting process, but neither agency has compiled and published the data. A new, comprehensive inventory is needed.

At the national level, the Office of Technology Assessment (OTA 1992) estimates that surface impoundments handle perhaps 70% of all Subtitle D wastes, which include all nonhazardous wastes. Such impoundments generally are unlined and unmonitored. It might be reasonable to assume that the same percentage of Subtitle D wastes are handled in Illinois in the same way, especially for the older impoundments.

Regulations

The IEPA and IDMM are responsible for regulation of surface impoundments in Illinois. All major impoundment categories defined in the introduction are regulated to some degree, depending on the type and amount of fluid to be impounded. Strict requirements are set for the design and operation of regulated impoundments; for example, oil and gas waste impoundments and impoundments to treat, store or dispose of hazardous wastes must be lined or constructed of materials that will not allow seepage or overtopping. Hazardous waste impoundment operators are required to document the type and amount of fluid put into the impoundment, as well as to provide a plan for inspection and closure of the impoundment to ensure compliance. Not all impoundments are as strictly regulated as those receiving hazardous wastes. Most agricultural waste impoundments, for example, are neither aggressively recorded nor regulated.

Environmental Damage and Management

The IEPA found in their 1980 assessment that groundwater pollution occurred to some degree in a localized area of each surface impoundment; 1,211 water samples were taken from monitoring wells and later analyzed (Piskin et al. 1980). As shown by the 1980 study, the use of groundwater monitoring wells is one means of establishing the presence or absence of leachate from impoundments and thus assessing the potential for degradation of groundwater. The practice of groundwater monitoring around surface impoundments is implied by regulations setting groundwater quality standards, but it is not specifically required in Illinois (R. Pinneo, IEPA, personal communication 1993). Not all impoundments currently have monitoring wells associated with them, thus it is difficult to assess how many impoundments are negatively impacting the environment. The IEPA may require, as part of the permitting process, that existing or new impoundments be monitored, depending on the construction of the facility, the nature of the surrounding geologic materials, and the nature and volume of the waste to be disposed of. Monitoring wells are required if the IEPA determines that the waste collected in an existing impoundment is toxic. Regulations require all hazardous waste disposal facilities (Subtitle C) to have monitoring wells.

Environmental impacts from both active and abandoned impoundments have been documented in Illinois. In 1980, groundwater pollution from active oil and gas waste impoundments was reported in the IEPA inventory. Other instances of suspected, but not documented, groundwater degradation due to oil and gas wastes were found in IEPA files. All were brine disposal pits; all were condemned by IDMM and eventually covered. An ISGS study (Hensel and McKenna 1989) of the environmental impacts of oil field brines impounded and subsequently covered in Clay County found contaminated groundwater in the vicinity of some buried impoundments. Despite remediation, covered pits in other counties may still be a source of contamination. Reports by the ISGS (Hensel and McKenna 1989), the IEPA (1978, Piskin et al. 1980), and the ENR (Sours et al. 1985) have attempted to define environmental damage from leaking brine impoundments in Illinois.

Research Needs

More work is needed to document the use and potential consequences of impoundments in industries other than oil and gas. The 1980 IEPA inventory documented incidents of groundwater pollution due to industrial sources and one incident related to a municipal impoundment. More documentation is needed to determine how frequently pollution problems are associated with impoundments.

Is the use of impoundments on the rise or decline? Which industries should be regulated? What are the types of waste streams going into impoundments in Illinois? Collecting this information could be useful for a study of risks to human health. The Congressional Office of Technology Assessment suggests that the research should be nationwide because no health risk studies have been conducted by regulatory agencies for nearly 15 years (OTA 1992).

The potential for negative health effects from waste disposal in unlined impoundments is highly variable. The number of people potentially impacted depends on the proximity of the population to affected aquifers and the extent to which they obtain their drinking water from the affected aquifer. Most mining, oil and gas, and agricultural waste impoundments are located in remote areas, where it is unlikely that large numbers of people would be affected should wastes contaminate the groundwater. By contrast, sewage and industrial impoundments are commonly concentrated near highly populated areas, where many people are likely to be affected should wastes contaminate an aquifer being used by a municipality.

The distribution of impoundments and any environmental problems associated with them calls for a statewide reassessment and recommendations for action to prevent or alleviate contamination from waste disposal into surface impoundments.

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LAND APPLICATION OF MUNICIPAL SEWAGE SLUDGE

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In 1972, Congress passed into law the Federal Water Pollution Control Act, Amendments of 1972 as P.L. 92-500. Title II, Section 201, Subsection "d" of this law charges the Administrator of the U.S. Environmental Protection Agency (USEPA):

The Administrator shall encourage waste treatment management which results in the construction of revenue producing facilities providing for:

1) The recycling of potential sewage pollutants through the production of agriculture, silviculture or aquaculture products, or any combination thereof;

2) The confined and contained disposal of pollutants not recycled;

3) The reclamation of wastewater; and

4) The ultimate disposal of sludge in a manner that will not result in environmental hazards.

In response to the fourth charge, in 1973 the Illinois Environmental Protection Agency (IEPA) commenced an initial review of the available literature, ongoing research, and federal regulatory efforts concerning land application of sewage sludge and wastewaters on agricultural land. This 1973 review considered soil contamination and plant uptake of heavy metals, introduction and environmental transport and fate of pathogens, and odors (Schaeffer 1987, Personal Communication). These preliminary data were the basis for the formation in February 1974 of the *Illinois Advisory Committee on Sludge and Wastewater Utilization on Agriculture Land* (IACSWUAL). The Committee's objectives were:

1) To make recommendations regarding acceptable storage, transportation and utilization of municipal sludges and wastewater for crop production on agriculture land;

2) To explore the potential health hazards associated with the storing, transporting and utilization of sludges and wastewater from a disease and heavy metal standpoint. This exploration shall include water, airborne and food chain considerations;

3) To encourage the responsible use of land application methods in the recovery of plant nutrients from sludges and wastewater in a manner that will not degrade the quality of the environment and which is consistent with the objectives of the Illinois Environmental Protection Act and the Federal Water Pollution Control Act of 1972;

4) To examine other feasible municipal sludge and wastewater applications to land and to develop application criteria.

Four subcommittees of the IACSWUAL considered "Pathogens and Air and Waterborne Viruses", "Heavy Metal and Plant Nutrient Loading Rates", "Odors", and "Social and Aesthetic Concerns". The Committee's pioneering report (IEPA, 1975) considered the economics and sociology of agronomic application of sludges, developed specific numerical guidance on nutrient and heavy metal loading rates, addressed the issue of viral and other pathogens, and provided deregulation recommendations. This report was the basis for IEPA's first regulations which are codified at 7 Ill. Reg. 16834, effective December 14, 1983, and are given in Title 35, Subtitle C, Part 391.

The regulations provide criteria for transporting, storing and applying sludge on land in an environmentally acceptable manner. The criteria apply to municipal and private domestic sewage and water treatment plants that land apply sludge for final disposal. Land application is restricted to sludges that have been determined to be nonhazardous and non-toxic. Land application is permissible at agronomic rates, i.e., at "an application rate of sludge sufficient to supply that quantity of plant nutrients that can reasonably be expected to be utilized by agricultural crops" (§391.102) as determined according to specific application design criteria (§391.401).

SLUDGE COMPOSITION

Table 15.1 summarizes the available data on metal concentrations in Illinois publicly owned treatment works (POTW) sludge (except the Metropolitan Water Reclamation District of Greater Chicago, MWRDGC). The data are arranged in strata according to the design capacity (in millions of gallons per day, MGD) of the POTW and whether or not the POTW has a pretreatment program. A pollutant was considered "detected" when it was present at a level above the analytical detection limit (DL) for the particular laboratory carrying out the analysis. A pollutant was "non-detectable" when its concentration was at or below a laboratory's detection limit; the table shows, for example, that different laboratories have different DL's for the same pollutant.

Table 15.1, part 1 shows that smaller POTWs tend to have lower concentrations of metals in their sludges than larger POTWs. This suggests that metals including arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), molybdenum (Mo), nickel (Ni), and zinc (Zn) come primarily from industrial sources which are more likely to discharge into larger systems. Some of the copper (Cu) and lead (Pb) in wastewater comes from leaching of domestic plumbing, and the remainder is from industrial sources.

The Table 15.1, part 2 shows the metal concentrations in sludges for POTWs with and without industrial pretreatment programs. Industrial discharges are usually to the larger plants, so it is reasonable that pretreatment programs are associated with larger facilities. However, pretreated wastes still contain some metals. Higher metal concentrations in sludges generated in pretreatment communities can be explained by assuming that metal concentrations in wastewater from non-industrial sources are about the same in both categories of POTWs but, even after pretreatment, industrial sources in heavily industrialized cities with pretreatment programs discharge wastewater with higher metal concentrations than industrial sources in the smaller, less industrial communities without pretreatment. Differences in sludge metal concentrations may also be related to possible skew in the data base toward lower concentrations. This can occur because POTWs without pretreatment programs which dispose of their sludge in landfills are not required to file sludge monitoring reports. To the extent POTWs with relatively high levels of regulated metals chose landfill disposal rather than land application, the data base systematically excludes these sludges (John et al., 1992).

SLUDGE "USE" AND "DISPOSAL"

A distinction is made between "using" and "disposing" of sludge. Sludge is "used" when it is applied at rates to enhance the growth of crops, grasses, trees or other vegetation. Sludge contains nitrogen and phosphorus, the primary plant fertilizers, and many of the metals contained in sludge (Table 15.1) are necessary -in small amounts- for plant growth. By increasing the organic content of soil, sludge also improves the soil's capacity to store and hold available water, thereby increasing its potential productivity and reducing its erosion potential. Examples of sludge use are land application on agricultural land, application on non-agricultural land, land reclamation, and landscaping. Sludge is "disposed" of when its nutrient values are not used. Examples of disposal are landfilling, incineration, and long-term surface disposal in sludge lagoons.

The U.S. Environmental Protection Agency (USEPA) considers five categories of sludge use or disposal, other than disposal in municipal landfills: land application, distribution and marketing, monofills, surface disposal sites, and incineration. The final rules issued by USEPA in the 19 February 1993 Federal Register (FR) apply to agricultural and non-agricultural application of sludge. USEPA's new Part 503.13 Rules for land application establish numerical limits for 10 heavy metals. USEPA deleted organic "pollutants from the part 503 regulation after the part 503 risk assessment was completed" (EPA 1993, FR 9384). The rules also address management practices, pathogen and vector attraction reduction, and monitoring and reporting requirements. The State and federal rules establish limits for concentrations in the sludge, annual and cumulative amounts added to the soil (see Table 15.2), and application procedures designed to ensure the protection of public health. The annual rates are expected to result in no significant uptake into crops over 20 years of land application.

Table 15.1, Part 1. Summary of available data on metal concentrations in Illinois POTW sludge[1].
Part 1. Effect of POTW capacity on sludge composition.

	Stratum 2 10-99.9 MGD				Stratum 3 1.0-9.9 MDG				Stratum 4 <1.0 MD				All POTW's			
	> DL[2]		≤ DL		> DL		≤ DL		> DL		≤ DL		> DL		≤ DL	
	N	Mean	N	Mean DL	N	Mean	N	Mean DL	N	Mean	N	Mean DL	N	Mean	N	Mean DL
Design Capacity (MGD)[3]	20	20.98	--	--	93	2.93	--		81	0.48			194	3.77		
As	9	15.1	4	8.2	14	5.9	9	28.0	0	--	1	4.0	24	9.4	15	19.4
Cd	15	12.0	2	6.9	82	9.0	5	4.6	76	7.7	5	8.2	192	8.9	17	14.3
Cr	9	311.8	0	--	34	160.6	0	--	13	90.6	2	17.5	59	164.4	3	58.4
Cu	17	840.4	0	--	86	796.2	0	--	80	945.6	0	--	207	900.9	0	--
Pb	18	274.4	0	--	84	161.1	2	52.2	70	159.9	9	63.0	191	165.3	16	62.3
Hg	14	46.8	1	0.5	25	13.6	4	10.1	2	1.9	0	--	45	22.3	5	8.2
Mo	1	50.0	0	--	2	8.8	2	5.4	0	--	0	--	3	22.5	2	5.4
Ni	17	71.4	0	--	84	93.7	3	5.6	76	56.0	4	40.2	197	73.0	11	49.8
Se	6	8.4	6	13.2	16	5.4	10	12.9	0	--	2	5.7	22	6.2	21	11.8
Zn	17	1337.0	--	0	87	1242.5	0	--	80	1100.2	1	5.8	207	1148.5	2	17.9

[1]Sludge concentrations and detection limits (DL) in Mg/Kg (dry weight basis)
[2]Each laboratory establishes a concentration, termed the detection limit(DL), below which the concentration of a specified metal cannot be quantified.
[3]N and Mean are for all treatment plants in that stratum.

Table 15.1. Summary of available data on Metal concentration in Illinois POTW sludge[1]
Part 2. Effect of industrial pretreatment programs on sludge composition.

	POTWs with Pretreatment Programs				POTWs without Pretreatment Programs			
	>DL		≤DL		>DL		≤DL	
	N	Mean	N	Mean DL	N	Mean	N	Mean DL
Design	36	12.1			147	1.5		
As	21	10.1	14	20.5	3	4.3	1	4.0
Cd	35	16.5	2	6.9	157	7.2	15	15.3
Cr	26	268.0	0	--	33	82.7	3	58.4
Cu	37	1028.3	0	--	170	873.2	0	
Pb	38	258.5	0	--	153	142.2	16	62.3
Hg	35	19.8	4	10.2	10	31.1	1	0.0
Mo	3	22.5	2	5.4	0	--	0	--
Ni	37	148.0	0	--	160	55.6	11	49.8
Se	22	6.2	15	13.2	0	--	6	8.3
Zn	37	1617.9	0	--	170	1046.4	2	17.9

[1]Sludge concentrations and detection limits (DL) in mg/kg (dry weight basis)

Table 15.2. Final USEPA and existing IEPA pollutant limits for agricultural land application.

	USEPA Mean Concentration (mg/kg)[1]	USEPA Annual pollutant loading rate (kg/ha)	USEPA Cumulative pollutant loading rate (kg/ha)[2]	IEPA Annual pollutant loading rate (kg/ha)	IEPA Cumulative pollutant loading rate (kg/ha)
Organic pollutants:					
Polychlorinated biphenyls				Note 3	
Metals:					
Arsenic	41	2.0	41		112, Note 4
Cadmium	39	1.9	39	2.2	11
Chromium	1200	150	3000		
Chromium - trivalent				100	3940, Note 4
Chromium-hexavalent				49	493, Note 4
Copper	1500	75	1500		280
Lead	300	15	300		1120
Mercury	17	0.85	17	7.8	Note 4
Molybdenum	18	0.90	18	Note 5	
Nickel	420	21	420		112
Selenium	36	5.0	100	Note 5	9, Note 4
Zinc	2800	140	2800		560
Antinomy					785, Note 4
Silver					200
Manganese					1009

[1]Concentration in sludge, dry weight basis, monthly average
[2]Cumulative rate based on 20 years application at the annual pollutant loading rate
[3]Sludge containing 10 mg/kg PCB or more must be incorporated when applied to land used for producing animal feed.
[4]IEPA standards for antinomy, arsenic, chromium, mercury, selenium and silver are applied only where IEPA determines these metals should restrict application rates.
[5]IEPA restrictions use of crops for forage if sludge concentration of molybdenum or selenium exceeds 4.0 mg/kg.

SLUDGE GENERATION, USE AND DISPOSAL IN ILLINOIS

In July 1974, IEPA provided the following partial results of its sludge disposal survey of POTWs. In reference to Table 15.3, the report states that "...the sample is not entirely complete in that some regions were only to report a portion of their plants." Unfortunately, no additional information was provided about which regions were, or were not, included.

IEPA has maintained a simple database of municipal sludge and wastewater application information for the past few years, but it has not analyzed these data. The following discussion is taken from two analyses of municipal sludge prepared for ENR (Skelton, 1990; John, 1992). IEPA maintains land application data for industrial wastes (such as cannery wastes) as part of a facility's permit, but does not compile or analyze these data. Some information about industrial sludges is presented in other sections.

State and federal policies officially promote land application, and it is the practice toward which POTWs are moving. For example, dewatering of sludges is required prior to landfilling and the state has mandated increases in landfill "tipping" fees. Nearly 80 percent of the POTWs in the state land apply sludge. IEPA reported that, in 1989, 462 Illinois POTWs outside the MWRDGC transferred 178,529 metric tons of sewage sludge, of which 79,468 metric tons (45 percent) were landfilled. The major "use" of sludge was application of 59,993 metric tons (34 percent) to agricultural land. 20,168 metric tons (11 percent) were put into storage lagoons. The remaining 10 percent were used as follows: 2 percent were put on dedicated land, 2 percent were used for land reclamation, 1 percent went to horticulture, 2 percent were publicly distributed, and 3 percent went to other purposes. In comparison, the MWRDGC transferred 309,523 metric tons of sludge that same year, of which 48 percent went to land reclamation of a closure site, 40 percent was landfilled, 9 percent was used for horticulture and 2 percent was publicly distributed. These distributions of sludge are depicted in Figures 15.1 and 15.2.

Illinois has a large number of smaller POTWs and a few large POTWs that produce much of the sludge (Figures 15.3, 15.4). Of the 462 POTWs (excluding the MWRDGC) in the 1989 IEPA report, 431 individually produced less than 1,000 metric tons of sludge and in total produced only 69,742 metric tons. The other 31 POTWs that each produced more than 1,000 metric tons in total accounted for 108,787 metric tons, meaning that 7 percent of the POTWs produced 61 percent of the sludge. Only 63 POTWs landfilled all or part of their sludge in 1989 (Figure 15.5). Landfilling accounted for 45 percent of the sludge produced and tended to be concentrated in a relatively few urban areas of the State. Illinois sludge use and disposal practices are thus characterized by a large number of smaller POTWs that typically apply their sludges to agricultural land (Figure 15.6) and a few larger POTWs that typically dispose their sludges by landfilling and lagoon storage. Some larger POTWs are shifting to application of their sludges to agricultural land: more than 12 percent of the sludge that was landfilled in 1989 was applied to land in 1991. There is almost no shift away from land application, and Illinois landfill regulations that went into effect in 1989 will discourage landfilling and will encourage land application.

The amount of land required for application of sludge is not large relative to the farmland available in the State. Based on the average plant available nitrogen in Illinois sludge and the average corn yield in the State, it would require 123,000 acres of land, or 0.5 percent of the more than 24.7 million acres of crop land in Illinois, to apply all of the wastewater sludge produced in the State including the sludge produced by the MWRDGC. It is only in the Chicago urban area where land availability is a problem. However, the annual rhythm of agricultural activity, the weather, demographics and urban development all contribute to reducing the amount of sludge that is applied to agricultural land.

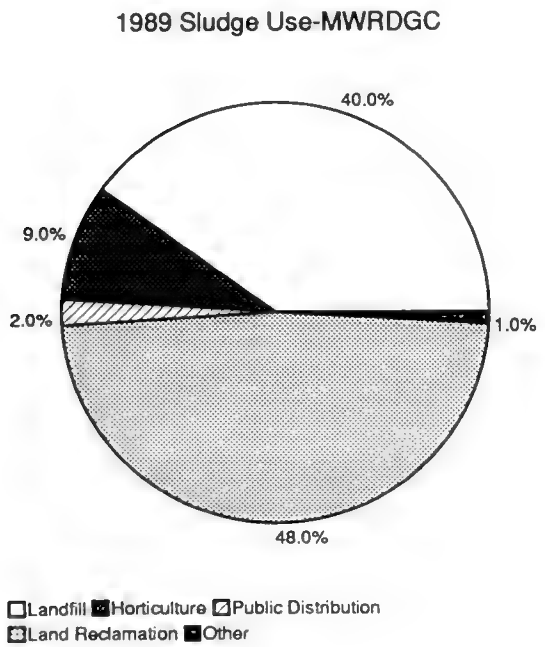
The basic difference between sludge production and agricultural activity that has to be bridged to readily allow application of sludge to agricultural land is that sludge is produced every day at the treatment plant while it can be applied to land only in so far as it fits into the agricultural cycle of planting, cultivating, growing and harvesting. That difference drives many of the costs associated with land application and for some POTWs rules out land application as a management option. From the farmer's perspective, the two-year value of the nitrogen and phosphorus in the average sludge applied at the agronomic rate for corn is $41 per acre. Other readily monetized benefits to the farmer of sludge application (e.g., limestone application, soil testing, incorporation that takes the place of plowing) bring the total monetized benefit of sludge application to the farmer to $74 per

Table 15.3. Partial results of IEPA's 1974 sludge disposal survey.

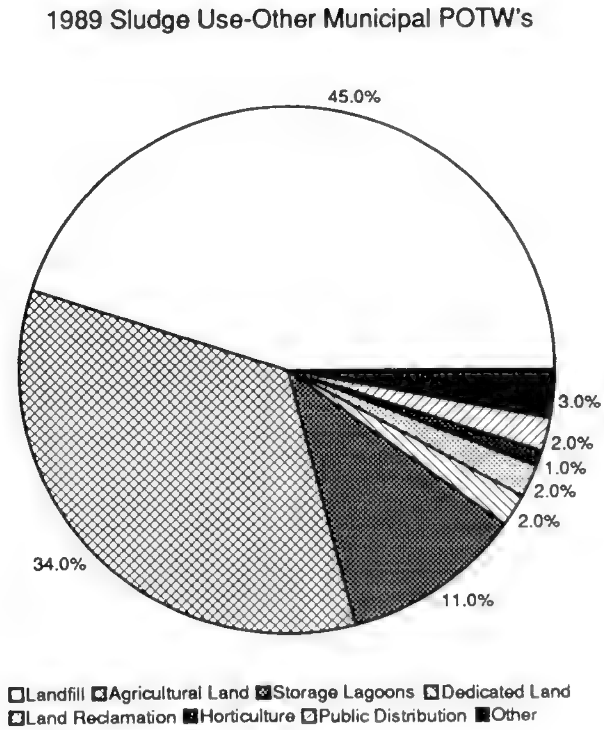
Approximate Number in State		No. of Responses	Land Appl. Wet %	Land Appl. Dry %	Land Appl. Other %[1]	Lagoon %
Municipal	790	353	25% (90)	52% (184)	14% (50)	9% (29)
Industrial	400	81	38% (31)	6% (5)	43% (35)	13% (10)
State/Federal	75	39	28% (11)	25% (10)	36% (14)	11% (4)
Other	1200	246	67% (165)	6% (15)	26% (64)	1% (3)

[1]Land application method not specified.

Source: IEPA, 1974.



Source: IEPA
Figure 15.1



Source: IEPA
Figure 15.2

SLUDGE VOLUME Quantity Produced (metric tons)	FACILITIES BY REGION I	II	III	IV	V	VI	VII
1 - 25	21	16	15	12	9	12	15
26 - 50	23	12	11	21	9	12	12
51 - 100	9	19	11	10	8	10	6
101 - 200	3	23	12	8	4	7	7
201 - 500	8	23	9	8	5	4	3
501 - 1000	4	14	3	3	2	5	3
1001 - 2000	1	9	0	2	1	4	0
2001 - 5000	0	5	2	0	2	3	0
5001 - 10000	0	3	1	1	0	0	0
10001 - 20000	1	0	0	0	0	0	0
20001 - 50000	0	2	0	0	0	0	0
50001 or more	0	1	0	0	0	0	0

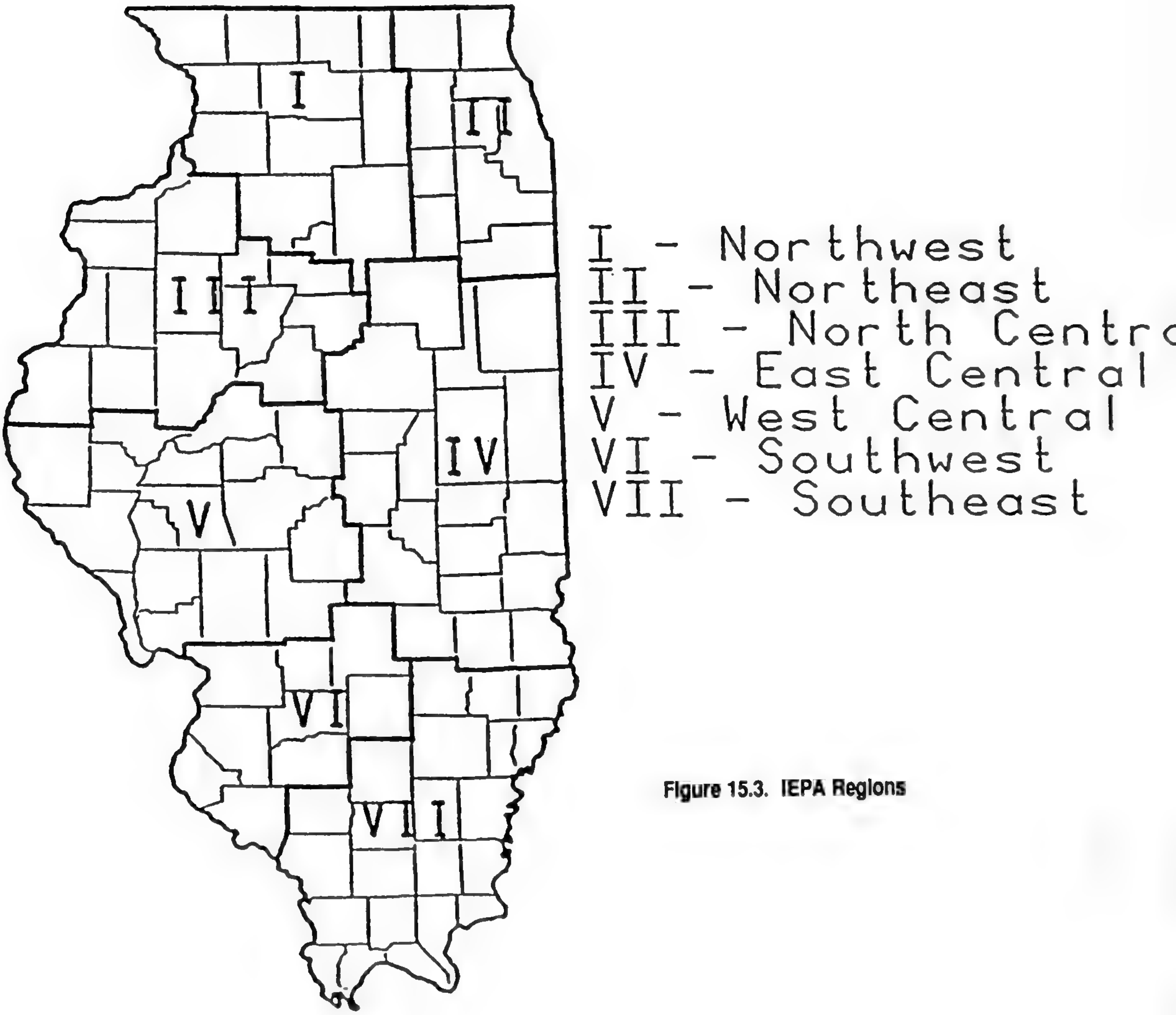


Figure 15.3. IEPA Regions

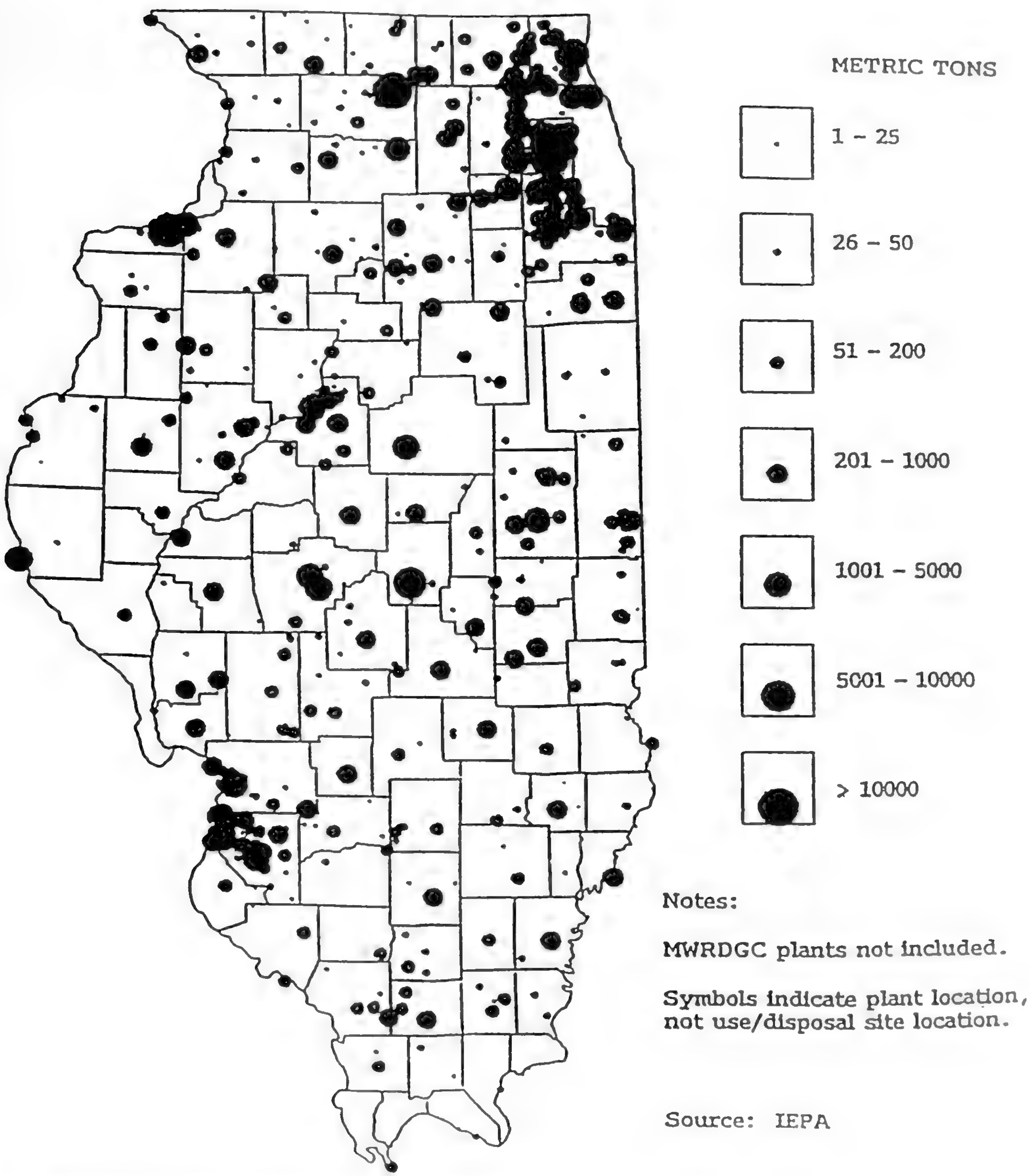


Figure 15.4. Total annual sludge production by Illinois POTW's.

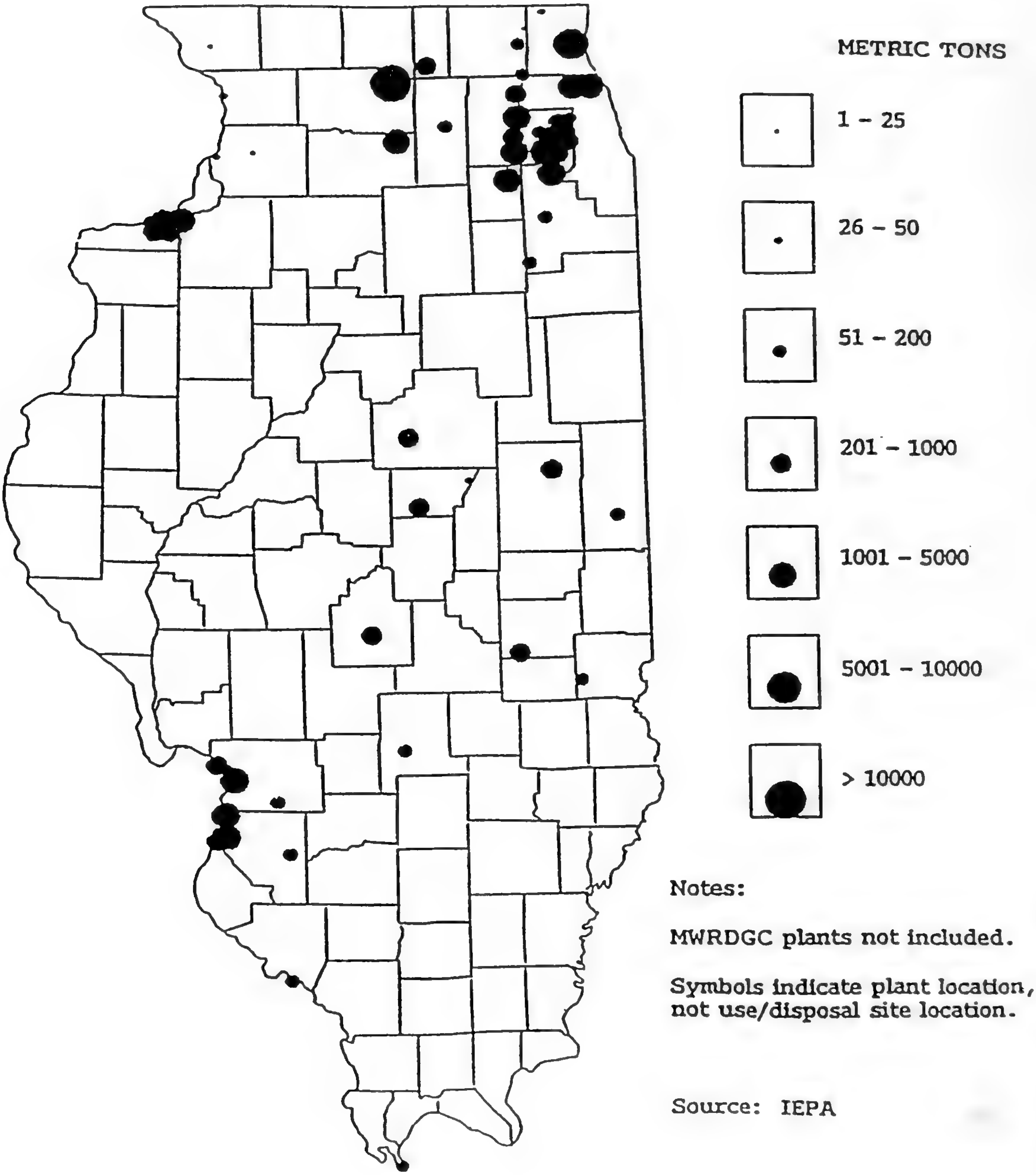


Figure 15.5. Landfill disposal of Illinois POTW sludge.

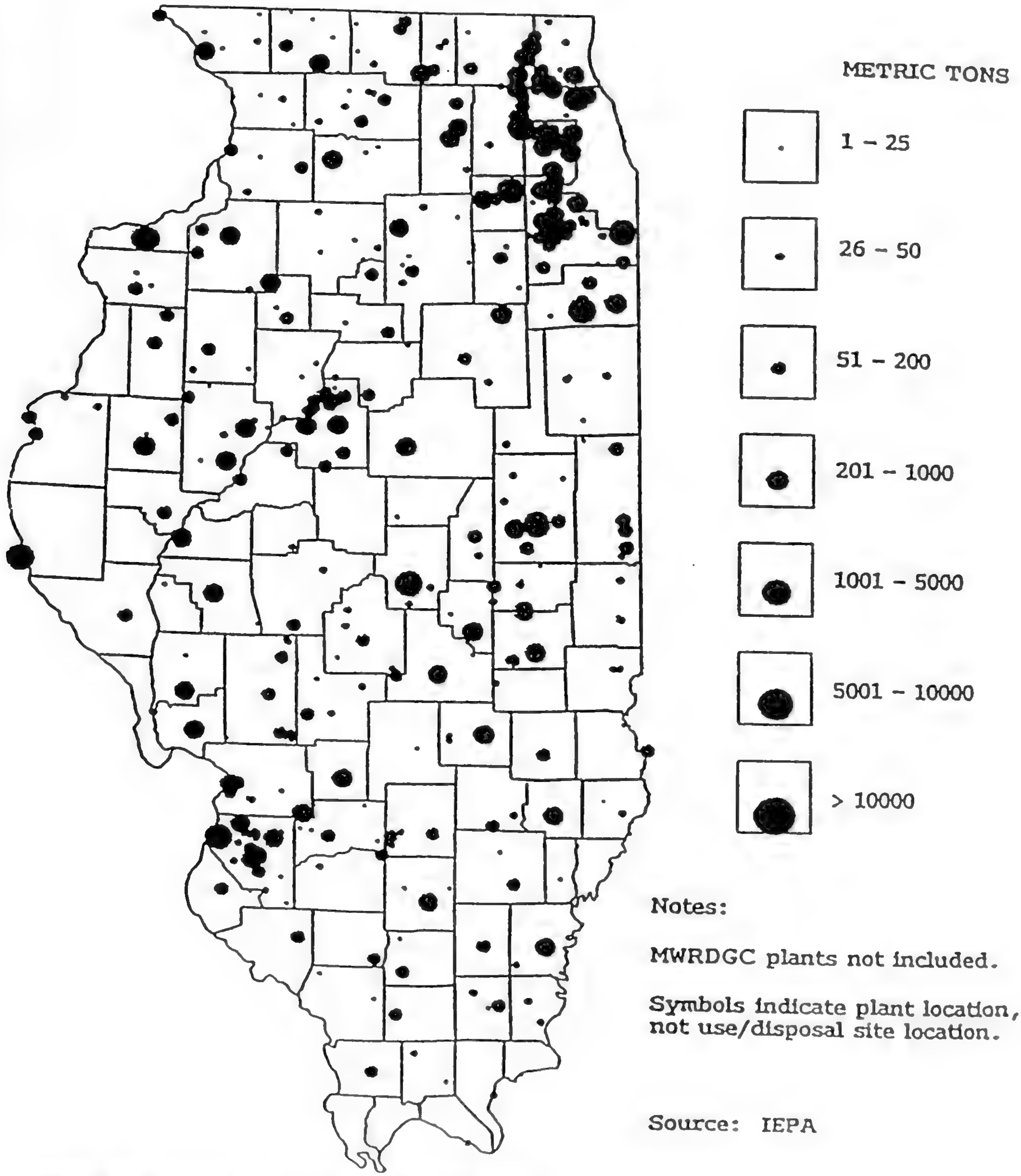


Figure 15.6. Agricultural land application of Illinios POTW sludge.

Table 15.4. Costs (1991) for transporting liquid sludge at 3 and 6 percent solids and dewatered sludge at 20 percent solids for landfilling.

Distance Miles	Liquid $/dt 3%	Liquid $/dt 6%	Dewatered $/dt	Difference $/dt 3%	Difference $/dt 6%
5	46.60	23.30	14.13	32.47	9.17
10	70.10	35.05	24.42	45.68	10.63
20	125.06	62.53	39.79	85.27	22.74
40	218.42	109.21	65.22	153.20	43.99

acre, and unmonetizable benefits (e.g., micronutrients, soil enhancement) raise the farmer's benefit.

The greater urbanization and population densities in the collar counties around Chicago result in larger treatment plants and more sludge to dispose of in an area where there is not much agricultural land, and where the remaining agricultural land is giving way to development. The crowding affects both the treatment plant site, and processing and potential application sites. The lack of storage makes land application of the sludge either very expensive or impossible. Another effect of crowding is that application sites become more distant and transportation costs increase. Haul distances have doubled in the last seven years and runs are seldom less than 10 miles. In order to reduce hauling costs, treatment plants in this part of the State dewater their sludge, which is expensive. The costs for transporting liquid sludge at 3 and 6 percent solids and dewatered sludge at 20 percent solids to a landfill are shown in Table 15.4.

Landfilling costs and contracts costs for liquid application of sludge are also going up rapidly and substantially. For example, a price increase of a half cent a gallon for land application translates into a $20 to $50 per dry ton increase depending on the solids content of the sludge.

According to the 1980 U.S. census, the number of Illinois households with septic tanks was 658,378 (15.3 percent of all Illinois households). The trend is down: septic systems were used by 598,125 households (14.2%) in the 1990 census. Nearly 200 haulers of septage now land apply about 2,400 dry metric tons (78,000 cubic yards as liquid) of septage annually. New federal requirements for lime stabilization of land-applied septage is expected to cause many of these haulers to shift to POTW disposal. The available data suggests that larger haulers already tend to use treatment works rather than farmland. Because most landfills now refuse to accept septage, suburban septage pumpers are placing increased reliance on POTWs. In the past, many POTWs either did not accept septage or charged high fees and imposed various restrictions. However, a State law enacted in 1991 requires POTWs to accept for treatment any septage generated within the county.

In 1991, approximately 395,000 dry tons of sludge were produced in Illinois by 453 POTWs. Twenty five are lagoon-type facilities which are removing accumulated sludge. The other 428 plants are mechanical plants which produce sludge on a regular basis. Table 15.5 gives the 1991 sludge application data by transfer method, percent of total sludge transferred, and number of facilities using each method.

The largest single sludge producer is MWRDGC which produced approximately 50% of the sludge generated in the State in each year since 1985. In 1991, MWRDGC sludge accounted for 92% (88,100 dry tons) of the sludge disposed on dedicated sludge disposal sites. Application of MWRDGC sludge to a closure site accounted for 93% (115,452 dry tons) of the sludge disposed in the "other methods" category (Table 15.5).

Of the 453 POTWs disposing of sludge in 1991, 351 had active sludge disposal permits. The remaining 102 POTWs include facilities which landfill their sludge, hold their sludge in storage lagoons on a long term basis, discharge their sludge to other POTWs for treatment and handling, or apply their sludge without a valid State operating permit.

Figure 15.7 shows the trends for selected heavy metals concentrations in MWRDGC sludge. The figure shows that the median concentrations of cadmium, chromium, copper, lead, and zinc have declined since 1978. The similarity in the rates of decline (as determined by the slopes of the lines) implies basic changes in the composition of the raw wastes, and provides evidence of the effectiveness of MWRDG's industrial pretreatment programs.

Table 15.5. IEPA sludge application data for 1985-1991.

	1985		1987		1988		1989		1990		1991	
Transfer Method	Dry Tons	Percent	Dry Tons	Percent	Dry Tons	Percent	Dry Tons	Percent	Dry Tons	Percent	Dry Tons	% of Total
Agriculture Land Use	---	---	95,419	20.7	96,603	20.1	63,279	9.1	53,312	13.8	90,289	18.7
Dedicated Land Disposal Site	---	---	4,548	1.0	4,548	<1	362,029	52.6	10	<1	94,939	19.6
Land Reclamation Use	---	---	105,752	22.9	105,752	22.9	3,320	<1	44,451	11.5	6,754	1.4
Horticultural Use	176,063	39.2	7,457	1.6	7,457	1.6	3,305	<1	3,086	<1	11,110	2.3
Public Distribution Use	---	---	9,287	2.0	9,287	2.0	51,223	7.4	3,353	<1	7,032	1.5
Dry Storage	---	---	---	---	---	---	---	---	---	---	16,013	3.3
Storage Lagoons	15,307	3.4	8,694	1.9	8,694	1.9	22,511	3.3	18,972	4.9	27,191	5.6
Landfill	66,177	14.7	224,783	48.8	224,783	48.7	174,447	25.3	169,770	43.9	106,859	22.1
Land Application Use	191,899[1]	42.7	---	---	---	---	---	---	---	---	---	---
Other	---	---	4,451	---	4,451	<1	8,214	12	92,887[3]	24.1	123,903	25.6
Total Sludge Transferred	449,446	460,391	461,858	688,328[2]	385,841	476,134[4]						
Number of Generators			440									

[1]In 1986, land application included use on farmland, disturbed soils, public distribution, horticultural use and other beneficial uses. Of the 462 publicly-owned mechanical plants in Illinois, approximately 244 permitees had valid operating permits for land application of sludge from 291 facilities. Approximately 116 facilities were unpermitted and 55 utilized landfilling or storage as their only disposal mode.

[2]In 1989, 450,180 try tons of sludge were generated; total includes sludge stored in previous years and applied in 1989.

[3]Quantity includes 80,682 dry tons disposed of at 103rd and Doty site by MWRDGC. MWRDGC produced 254,510 dry tons (65%) of the State's production.

[4]The quantity disposed is greater than the quantity produced in 1991 due to the inclusion of sludge stockpiled in previous years and disposed of in 1991.

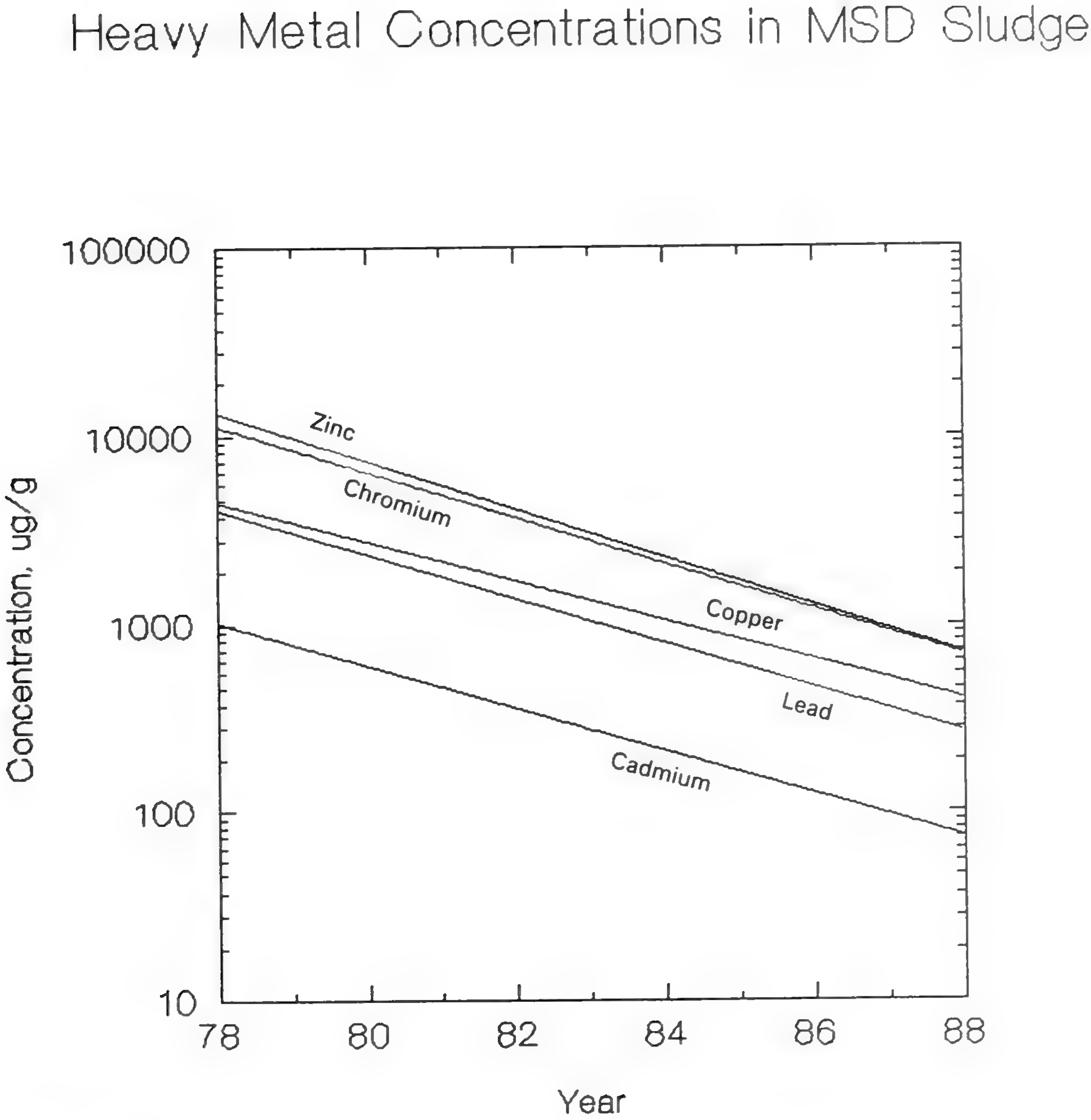

Heavy Metal Concentrations in MSD Sludge
100000
10000
1000
100
10
Concentration, ug/g
Zinc
Chromium
Copper
Lead
Cadmium
78
80
82
84
86
88
Year

Figure 15.7

SOURCES

Federal Register; 13 February 1993; 9384.

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UNDERGROUND INJECTION WELLS

Lisa R. Smith
Illinois State Geological Survey

The Safe Drinking Water Act (SDWA) was adopted by Congress in 1974 for the purpose of ensuring that public water supply systems meet minimum national water quality standards (DiNovo and Jaffe 1984). Not only did this legislation establish drinking water quality standards, it also provided for the Underground Injection Control (UIC). The objective of this program is to protect underground sources of drinking water from possible contamination by the underground injection of wastes (Burch et al. 1987). The State of Illinois received primacy for the UIC program in February 1984. As of mid-1993, however, the Illinois Environment Protection Agency (IEPA) was considering returning primacy for part of the UIC program (Class I and Class V wells) to the U.S. Environment Protection Agency (USEPA). The USEPA will determine whether or not to accept primacy for the Illinois UIC program in early 1994.

Underground injection is defined as the controlled subsurface emplacement of fluids into select, buried geologic formations. Fluid is injected through a bored, drilled, or driven well, or through a dug well in which the depth is greater than the largest surface dimension (modified from Illinois Admin. Code 35, Part 730.103).

The technology for underground injection was developed and used by the oil and gas industry in the 1930s. The practice of injecting fluids underground has become an important part of oil-producing operations. Fluid is injected into underground formations for two reasons: to dispose of waste water produced along with oil, and to recover more oil from a producing formation (API 1954).

The concept of disposing of industrial wastes in this manner was first put forward in the 1950s, but it was not attempted in Illinois until 1965 (Brower et al. 1989). As disposal of wastes into surface waters and on land became more restricted (after the enactment of federal and state environmental laws), underground injection of liquid wastes gradually increased. The SDWA resulted in scrutiny of underground injection, just as the adoption of the Resource Conservation and Recovery Act (RCRA) focused attention on the disposal of hazardous waste. In Illinois, the number of wells for injecting hazardous waste has decreased since the RCRA was enacted in November 1980 and Illinois received primacy in 1984.

Five broad classes of injection wells are recognized by the USEPA and regulated by the UIC program:

Class I wells are used to dispose of hazardous and nonhazardous industrial and municipal waste below the lowest underground source of drinking water (USDW). (Note: a USDW can be an aquifer, part of an aquifer, or zone of aquifers containing enough groundwater to supply a public water system, or containing groundwater with less than 10,000 mg/L total dissolved solids. A USDW is not an equivalent term for an aquifer, but one must have an aquifer to have a USDW.)

Class II wells are used to dispose of wastes associated with the oil and gas industry.

Class III wells involve injection with solution mining or in situ gasification of oil shale and coal, and the recovery of geothermal energy.

Class IV wells have been banned in the United States because they involve injection of hazardous waste into or above a USDW.

Class V wells are defined as all other nonhazardous injection not covered by the first four. In Illinois, these are commonly used to dispose of stormwater runoff, sewage, and heat pump effluent.

Waste injection wells in Illinois are all in classes I, II, and V. There are no Class III wells in Illinois, and Class IV wells are prohibited.

UNDERGROUND INJECTION: CLASS I WELLS

Six Class I injection wells, including one operational standby well, are operating at five industrial sites in Illinois. These deep injection wells range in depth from 2,737 feet to 5,524 feet (IEPA, personal communication 1993).

The first industrial disposal well in Illinois was constructed in 1965, and plugged and abandoned in 1989. By 1976, all existing deep injection wells had been constructed. The life expectancy of a properly managed deep injection well is approximately 20 years. The IEPA is currently reviewing an application for a replacement well for an industrial disposal well constructed in 1966 (IEPA, personal communication 1993).

Class I wells in Illinois are used to dispose of more than 300 million gallons of industrial waste per year (Brower 1989). The waste streams, classified as both hazardous and nonhazardous, are largely water (70–95% of the total waste volume). Acids (HCl, H_2SO_4 and HF) used in industrial processes are the most common constituents of the waste streams. Other significant constituents include caustic soda, pesticides, fluoride, mercury, arsenic, vanadium and chromium compounds, and chlorinated hydrocarbons.

The feasibility of the deep well injection system depends primarily on the geologic environment beneath the disposal site. At each well site the geologic environment consists of a permeable injection zone to hold the waste; thick, impermeable rock layers (confining layers) above and below the injection zone; and some sequence of rock units between the upper confining interval and the underground source of drinking water (USDW).

In Illinois, porous and permeable dolomite and limestone formations are used as injection zones for five of the wells, and a thick sandstone formation is used for the sixth. According to UIC regulations, Class I well operators must provide the USEPA with a petition that documents the capability of the confining layer to prevent migration of wastes for 10,000 years. It is known as a "Land Ban Petition." All petitions submitted from Illinois have been accepted (IEPA, personal communication 1993). Regulations also mandate that the total dissolved solids content of any groundwater in a formation to be used for Class I disposal must be more than 10,000 mg/L. Groundwater containing less than 10,000 mg/L is reserved as a potential underground source of drinking water.

The regional geology of Illinois is characterized by widespread distribution of numerous rock units deposited in a broad depositional basin. Selected limestone, dolomite, and sandstone formations lie below all underground sources of drinking water across the central two-thirds of the state and meet the other regulatory requirements for disposal of industrial wastes in Class I wells. Figure 16.1 is a map view of the uppermost geologic units that contain potential disposal zones. The accompanying north-south profile view shows the subsurface relationships of these units.

The Environmental Risks of Waste Disposal

A fundamental requirement for every Class I disposal system is long term confinement of waste in the disposal zone. Any injected waste or formation water pushed out of the disposal zone by the injection pressure gradient buildup represents a potential risk to overlying USDWs. The degree of risk associated with the potential loss of confinement integrity can be assessed by evaluating (1) the features in the geologic environment that could act as avenues of escape for injection zone fluids, and (2) the nature of the flow system. Escape routes include faults, joints, and fractures transecting the primary confining interval; improperly plugged wells penetrating the rocks used for disposal; poor annular cement in the disposal well; fracturing induced by excessive injection pressure; and excessive lateral migration of low-density waste from disposal sites adjacent to the fresh water/brine boundary.

If a chemical reaction leads to reduced injection potential in the disposal zone, an increase in injection pressure will be required to maintain flow rate. Elevated injection pressures are permissible up to the limit fixed in the permit; however, as the pressure in the injection zone increases, a larger driving force (hydraulic gradient) is exerted across the confining units. Although the permit allows injection at pressures up to the maximum limit, the opportunity for loss of fluid through the confining unit increases as the injection pressure in the injection zone increases.

Blow-outs from the production of a gas phase must be avoided. Gas that rises into the tubing of the well and displaces the fluid column may place excess pressure on the upper portion of the well, possibly causing a blow-out. Proper management can avoid this.

Acid waste injected into carbonate disposal zones could, after a considerable period of time, dissolve enough rock in the disposal zone to cause subsidence at the base of the overlying confining unit. An evaluation of this situation should be undertaken to determine the pattern of solution development, the amount of solution required before subsidence begins, and the maximum allowable subsidence permitted before confining unit integrity is placed at a significant level of risk.

Seismicity represents an unknown factor in deep well disposal that must be given careful consideration. The potential magnitude of seismic events can be

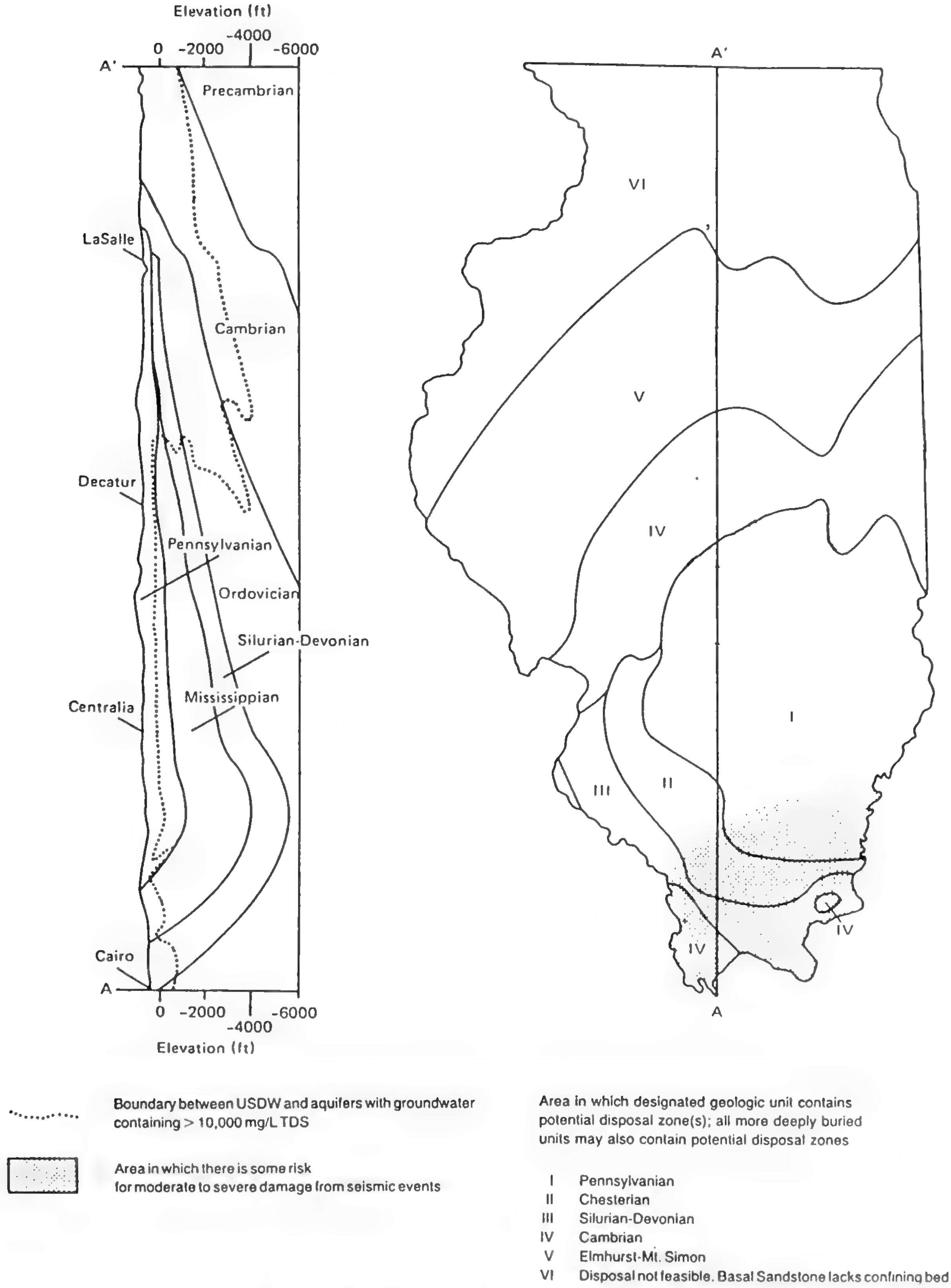

Figure 16.1 Uppermost geologic units that have contained disposal zones and the subsurface relationships of these units.

estimated with reasonable accuracy from historical records and from an evaluation of the shallow and deep geologic environments. Well design should take into consideration factors that will allow a well to be capable of maintaining integrity during a design earthquake (the type of earthquake used as a basis for anticipating and solving practical problems).

Current Status and the Environmental Implications

The IEPA considers underground injection a disposal option of last resort—to be used only when (1) the typical disposal options of waste reduction, recycling, and other treatments are not feasible, and (2) the geologic environment beneath the proposed disposal site meets established regulatory requirements. Assessment of the feasibility of deep well disposal includes technical considerations as well as environmental, social, and economic impacts.

The practice of deep underground disposal of industrial waste was reviewed in 1989 by Illinois State agencies in response to state and federal legislation. The study found some shortcomings and the UIC regulations for Illinois were amended in 1990 to impose stricter operating, testing and monitoring standards. The current status of Class I injection and its environmental implications are reviewed below.

Geologic formations currently being used for deep well disposal at five Illinois sites appear to be adequate to confine the injected volumes for the lifetime of the well (about 20 years). Four wells inject waste into the Eminence, Potosi, and Franconia dolomites; one injects into the Mt. Simon Sandstone. The remaining deep well injects a small volume of waste (less than 50 gallons per day) into Devonian-age limestones.

Injection pressures used at the wells are considerably lower than the limit at which fractures might begin to develop in the strata used for injection. Regulations requiring continuous monitoring of annular and injection pressures are strictly enforced because assessment of these two parameters is one method to evaluate the performance of an injection well. Pressure build-up and fall-off tests, which also indicate well performance, are also required for Class I wells in Illinois. Pressure build-up in an injection zone is greatest adjacent to the well bore and decreases to nearly zero at a considerable radial distance from the operating well. This pressure build-up tends to increase with continued use of the well; and after a time, an area in which the pressure buildup is large enough to produce an upward hydraulic gradient develops around the well. Currently available testing, monitoring and data analysis can be used to estimate the general pattern of this area and the capacity of the overlying primary confinement interval to retain the waste affected by this upward gradient. However, these data cannot be used to determine the specific location and hydraulic character of each potential fracture present in the confinement interval or to verify detailed aspects of waste and pressure distributions in the disposal zone or its primary confinement intervals. Artificial fracturing of the disposal zone is not permitted during disposal well construction, testing, and operation.

Current operating, testing, monitoring, and reporting regulations require that the injected fluid be analyzed with sufficient frequency to yield characteristic data. The waste stream or its anticipated reaction products must not react with the confining or injection zones so as to alter the permeability, thickness, or other relevant characteristics of the zone. The waste streams at six disposal sites are relatively stable in composition and volume and have not, for the most part, interacted adversely with fluid or rocks of the disposal zone to reduce or limit significantly the capacity of the disposal zone to accept the injected waste stream. According to Brower (1989), some minor and a few major problems have been reported with injected waste disposal/formation interactions. In each case, however, the affected well was repaired or restored to comply with the regulations then in effect, and no contamination of any underground source of drinking water was detected. Some chemical and physical changes in waste components are expected to occur after the waste is injected into a disposal formation, but these changes cannot be directly evaluated with current monitoring procedures. Modeling of predicted reaction paths is not required but some work has shown the feasibility of determining the fate of injects (Roy et al. 1988).

One monitoring well is currently associated with a deep injection site in Illinois. It will be used to detect leakage through the confining bed overlying a specific disposal formation. This monitoring well was completed in 1992 (IEPA, personal communication 1993). Monitoring can best be done in a saline aquifer (not a USDW) above the primary confining bed, where any waste passing through the confining bed can be detected. Direct monitoring through wells into the disposal zone is not advisable because each monitoring well completed in the injection zone provides a potential pathway for escape of the injected waste (Brower et al. 1989).

Fluid movement rates in deep subsurface environments range from much less than a few inches per year under natural groundwater flow conditions to much higher rates where injection occurs. During injection, the rate of movement is higher next to the well bore and decreases radially away from the well; the highest rates occur in the most permeable zones and adjacent to the well bore. Conditions in the disposal zone rock affect both the rate and pattern of this flow. A general picture of the flow characteristics and the radial uniformity of geologic conditions in the disposal zone can be obtained by evaluating monitoring and testing data. However, specific detailed information for these parameters is generally not available beyond the immediate vicinity of the well bore (Brower et al. 1989).

The operator is responsible for testing and must report quarterly to the IEPA. Recent changes and amendments to regulations controlling waste generation, storage, and disposal have encouraged existing Class I operators to continually review and, in some cases, implement changes in their UIC management practices. There is a trend toward reducing or eliminating hazardous waste components in injected waste streams and to reduce waste volume where possible.

UNDERGROUND INJECTION: CLASS II WELLS

When hydrocarbons are produced from subsurface reservoir rocks, varying amounts of water accompany the oil or gas to the surface. This fluid is known as produced water (API 1989). Produced waters are mixtures of the naturally occurring water in the geologic formation being drilled, naturally derived dissolved constituents (such as minerals and trace elements), and chemicals added for treatment (OTA 1992). Gas, oil, and saline water (brine) are trapped in porous, permeable rocks deep below the surface. Because gas has the least density, it fills the pores near the top of a trap. Oil is found just below the gas, and the typically denser, saline water occurs below the oil and gas. As the oil, gas, and brine are closely associated, all three are produced at some point during the lifetime of the well. The produced water is separated from the oil and must be disposed of or used in some environmentally acceptable manner.

Since the 1940s, produced water has been reinjected into the ground for waste disposal and secondary oil recovery or waterflooding (API 1954, OTA 1992). Waterflooding is the reinjection of produced water into the reservoir to force remaining hydrocarbons to migrate toward adjacent production wells. The USEPA has determined that produced water used for waterflooding is not a waste, but is beneficially recycled (API 1989). However, the sites where fluid is injected, either for waste disposal or waterflooding, are subject to UIC regulations (API 1989). In 1990, approximately 13,000 of these Class II injection wells (Figure 16.2) were documented in Illinois (IDMM 19-90).

The environmental risks of reinjection are basically the same, whether for enhanced recovery or for waste disposal purposes. Produced waters may be reinjected with or without treatment. Steps generally taken before wastes are reinjected into wells include (1) separation of free oil from produced waters, (2) storage of wastes in tanks, (3) filtration, and (4) chemical treatment (OTA 1992). When destined for disposal, produced waters are injected into deeper saltwater-bearing formations, the original reservoir, or a deeper, depleted reservoir.

Injection activities at active Class II wells are regulated, under the SDWA UIC program for oilfield-related fluids, by the Illinois Department of Mines and Minerals (IDMM) with some supervision by the IEPA and assistance from the Interstate Oil and Gas Compact Commission (IOGCC). (The IOGCC is an organization of the governors of 29 states producing oil and gas and has been assisting in developing state regulatory programs since 1935). Prior to 1984 and the Safe Drinking Water Act, no program or regulations existed to manage or monitor Class II injection. The IDMM began to organize the regulation of Class II wells in 1987 as a response to primacy granted by the U.S. Environmental Protection Agency. This UIC Class II program is now fully operational and regulates only the injection of fluids related to oil and gas production and hydrocarbon storage. These include produced waters and fluids used for secondary recovery as well as for disposal of brines.

The UIC program stipulates that regulation of Class II wells should not impede oil and gas production unless necessary to prevent endangerment of underground sources of drinking water. It further stipulates that this injection must take place below all formations containing an underground source of drinking water. The UIC regulations also require that

Class II Injection Wells

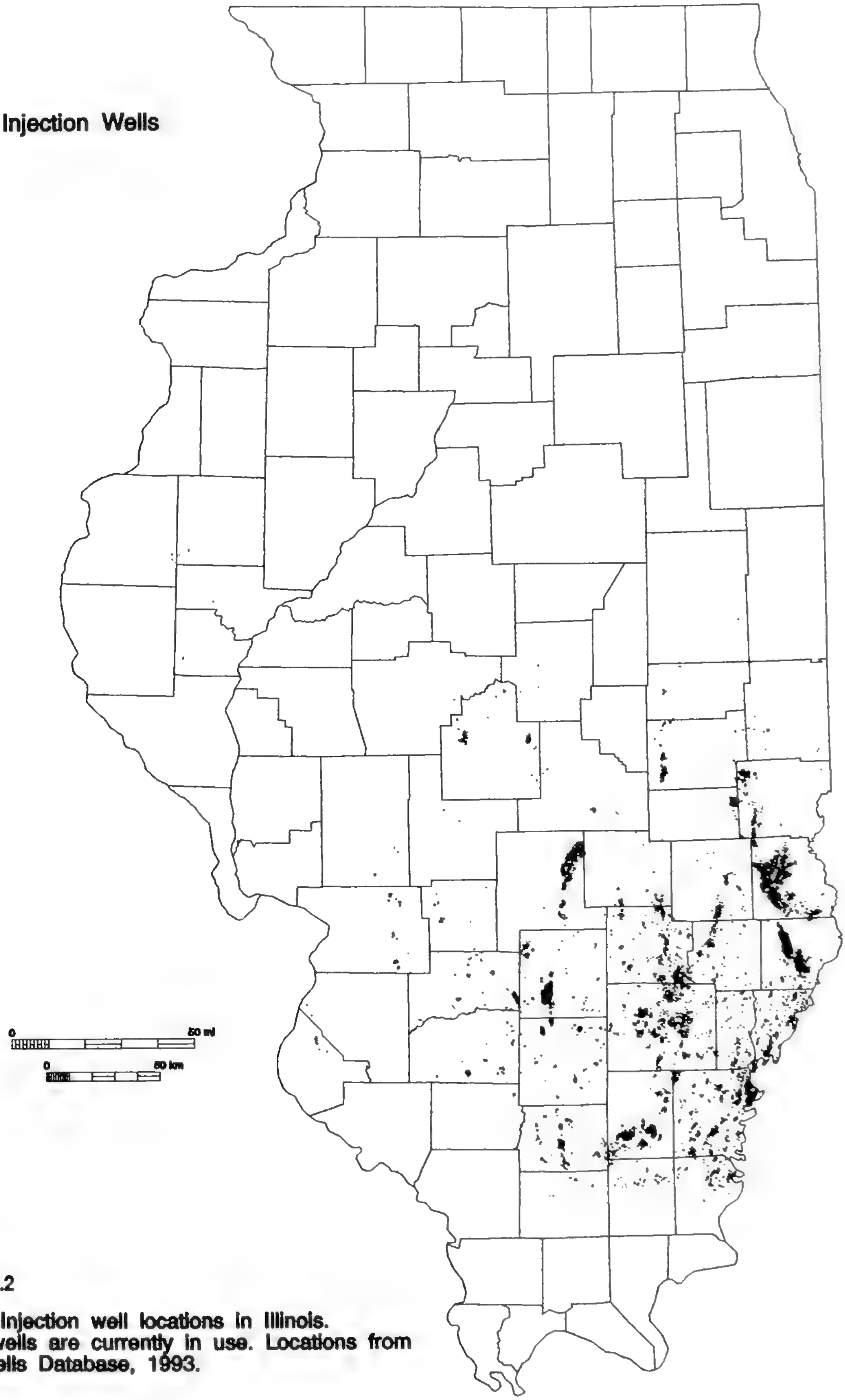

Figure 16.2

Class II Injection well locations in Illinois. Not all wells are currently in use. Locations from ISGS Wells Database, 1993.

periodic tests (every 5 years minimally) be conducted on the mechanical integrity of the wells (pressure test) and that a 1/4-mile radius around the well be reviewed for potential migration of injected fluids or brines from the site (IDMM 1993, OTA 1992, API 1989).

The Environmental Risks of Waste Disposal

Oil and gas operations should not put any environment of Illinois seriously at risk. Disposal of waste byproducts from oil and gas recovery operations are controlled by environmental regulations. Under these regulations, which provide for the management and disposal of wastes related to oil and gas production, the well operator is responsible and liable for protection of human health and the environment from harmful waste management practices and discharges. The regulations include the (1) Resource Conservation and Recovery Act (RCRA); (2) Safe Drinking Water Act (SDWA); (3) Clean Water Act (CWA); (4) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); (5) Clean Air Act (CAA); and (6) other state-specific regulations (API 1989). In Illinois, oil and gas exploration and production are regulated by the IDMM under Illinois Admin. Code 62, Part 240: the Illinois Oil and Gas Act.

In the past, oil and gas exploration and extraction procedures have locally degraded soil and water resources, and harmed wildlife in Illinois. According to the USEPA and the Office of Technical Assessment, injection wells have caused (1) groundwater degradation from improperly functioning injection wells; (2) damage to agricultural land, crops, streams, aquatic life, and other resources from produced water and drilling fluids; and (3) salt damage to groundwater, agricultural land, and domestic and irrigation water as natural brines seep from improperly plugged or unplugged abandoned wells (OTA 1992).

Preventing contamination of soil, vegetation, surface water, and potable groundwater is a primary goal during the operation of an injection well (Collins 1971, Hensel and McKenna 1989, API 1989, OTA 1992). The injected fluid must be confined within the injection zone. Class II injection wells are now designed to safeguard agricultural soils and surface water from well failure, which can occur in several ways. The older injection wells and associated pipelines used for disposal of oil and gas production wastes may be at high risk of failure and require increasing maintenance to avoid problems. Well failures also can occur because of design and construction problems, excessive injection pressures, and the corrosivity of the injected fluid.

Produced waters are generally highly corrosive because they contain many dissolved ions. Corrosion of the casing and well head through time can weaken the wells. IDMM regulations require setting of an external surface casing through the zone of freshwater-bearing subsurface formations to protect them from invasion by brines and hydrocarbons. If the internal casing that carries the brine in these disposal wells should leak, the brine can not threaten the subsurface freshwater environment. Corrosion of the pipelines that connect the production and injection wells can allow leakage. These leaks, which spill brine directly onto the surface, kill vegetation and contaminate soil. Operators may be able to remediate affected areas, should such spills take place.

Problems can also be caused by sediments or precipitates formed from brines that plug the geologic formation being used for disposal and force the use of higher injection pressures, which may rupture the input system (Collins 1971). The disposal formation can also become plugged through mixing of incompatible brines, if the geology of the formation into which the brine is being pumped is not clearly understood. If dissimilar incompatible brines are mixed through previously unpredicted pathways, such as faulting or fracturing, a precipitate may form. This precipitate can filter out on the face of the injection formation and reduce its permeability, causing problems that may lead to adverse environmental impacts (Collins 1971).

The environmental risk associated with the potential loss of confinement integrity may be assessed by determining whether any geologic features, such as fracturing, could allow migration of highly saline water. Monitored, regulated injection pressures are likely to pose only a minimal risk of fracturing. Unplugged or improperly plugged inactive or abandoned wells cannot be overlooked, as they may provide an route for injected fluids (IDMM 1990, OTA 1992). The potential for brine to escape through these wells is important to assess before injection of wastes.

Current Status and the Environmental Implications

Amount of Waste Generated The amount of fluids generated by oil and gas exploration and production depends on the level of industrial activity and the recovery stage of the oil reservoirs (USEPA 1987). In Illinois, there is no requirement to document how much waste is generated by exploration and production activities, so no data are available. But in 1985, according to American Petroleum Institute and USEPA estimates, approximately 1.2 billion barrels of produced water and more than 2.5 million barrels of drilling waste were produced and disposed of (OTA 1992). During the same year, 1,067 Class II permits were issued in Illinois.

From 1985 to 1990, the number of Class II permits declined to 233; however, the decline does not indicate a reduction in the production and injection of produced water. The quantity of water produced is dependent upon the method of recovery, the nature of the oil-producing formation, and the length of time the field has been producing. Generally, the ratio of produced water to oil or gas increases as the reservoir is depleted. In 1957, for example, an estimated 181 million barrels of water was produced along with 82 million barrels of oil (a ratio of 2.2:1); but by 1985, an estimated 1.2 billion barrels of water was produced along with 30 million barrels of oil (a ratio of 40:1).

Handling the tremendous volume of brine produced simultaneously with petroleum is potentially hazardous. Basically, the problem is to handle and dispose of the brine in such a manner that it does not contact soil or fresh water. Subsurface disposal of this brine and other oil and gas related waste into Class II wells has been on the increase since the early 1970s. In Illinois, the current practice is to reinject brine.

Regulations Pertaining to Operation Concerns have been raised at the national level about the effectiveness of injection regulations. Consequently, the federal EPA continues to evaluate the UIC Class II program. A recent USEPA evaluation indicated a need for (1) further study of risks associated with abandoned oil and gas wells; (2) additional evaluation of state "area of review" (1/4-mile radius) programs for existing wells; and (3) possible changes in Class II well construction requirements (USEPA 1987).

In 1991, Illinois responded by adopting new rules on Class II injection well construction and operation. Temporary abandonment rules, effective since January 1991, have established a review process for production and Class II wells. The process is intended to ensure that wells left unplugged for purposes of enhanced oil recovery at some future date are adequately monitored to protect freshwater zones. Before injection begins, operators are required to sample two or more freshwater wells within 1 mile of the injection site and record water quality parameters for the purpose of establishing base line data. Measurements in just two wells within 1 mile are not adequate, however, to characterize the hydrogeologic environment. Because no further monitoring is required by law, the first indication of an improperly functioning injection well may be detectable contamination in a local water well. But by then, the amount of contamination may be considerable.

Known Environmental Impacts In 1989, the U.S. General Accounting Office issued the report, "Drinking Water: Safeguards Are Not Preventing Contamination from Injected Oil and Gas Wastes," in which they documented causes and consequences of contamination from reinjecting fluids into subsurface rock formations throughout the nation. A few instances of saltwater contamination of aquifers from existing and abandoned Class II wells have been documented in Illinois (Ford et al. 1981), although no comprehensive report is available. According to the IDMM, the most severe cases of drinking water contamination reported in association with Class II wells occurred prior to implementation of the USEPA's UIC Class II well regulations. Since the implementation of UIC and the establishment of enforcement rules by IDMM, incidents have been minimized and the reported damage to soil and groundwater has been minimal (L. Bengal, IDMM, personal communication 1993). In field interviews conducted by the Illinois Department of Energy and Natural Resources (Sours et al. 1985), however, individuals admitted being aware of obvious violations, such as trucks emptying brine into local fields or streams. But they did not (or would not) report the incidents to proper authorities.

IDMM field inspectors issued 373 Notices of Violation related to field operations in 1990. Violations in firewall maintenance, well operations, general lease conditions, and equipment leaks as well as cases of illegal brine disposal (IDMM 1990) were cited. When confronted, operators have been quick to correct the conditions leading to a violation, so few civil penalties have been assessed. The IDMM takes the position that, as the oil industry becomes more familiar with the new regulations, it will deal with potential violations independently and responsibly.

Research Needs The full extent of damage from injection well failure is unknown. According to ISGS studies, more research is needed on (1) the potential for brine leakage from injection or disposal wells, and

(2) the upward migration of wastes through abandoned and unsealed boreholes. An inventory of reported cases of contamination, the first step in a study, could be followed by an assessment of possible techniques to detect contamination (Hensel and McKenna 1989).

UNDERGROUND INJECTION: CLASS V WELLS

On a national scale, many types of Class V wells are used to inject a variety of fluids into the subsurface. Most Class V wells are used for disposal. Class V injection does not include hazardous waste, but does involve injection into, above, or between underground sources of drinking water. There are 32 Class V injection practices recognized by the USEPA and summarized into eight well type categories (Table 16.1). According to the Ground Water Protection Council (formerly Underground Injection Practices Council or UIPC), these wells range in complexity from simple cesspools to sophisticated geothermal reinjection wells; thus they can be divided into "high-tech" and "low-tech" wells. High-tech wells typically have multiple casing strings and sophisticated wellhead equipment to control and measure pressure and inject high volumes of fluid into deeper formations. Low-tech wells generally have simple casing and surface equipment to inject into shallow formations by gravity flow or low volume pumps (UIPC 1987).

Almost 2,000 Class V wells were inventoried in 1987 in Illinois (Burch et al. 1987). The common well types include aquifer remediation wells; waste disposal wells; stormwater drainage wells; air conditioning/cooling water return flow wells; auto service station disposal wells; industrial process water and waste disposal wells; and agricultural drainage wells. The IEPA suggests that the number of Class V wells in Illinois may be much higher, as not all operators are aware of the reporting requirements (IEPA, personal communication 1993). Drainage and sewage-related wells make up the majority of Class V wells in Illinois (Underground Injection Practices Council 1987).

The Environmental Risks of Waste Disposal

The USEPA Office of Drinking Water and the Groundwater Protection Council suggests that the main risk of Class V injection is the potential to contaminate underground sources of drinking water (USDW). The potential for contamination depends on the proximity of the injection well to the aquifer; well construction, design, and operation; the nature of the contaminant in the waste stream, and the amount of waste injected.

Injection via Class V wells is largely into or above the underground source of drinking water (USDW), which is defined as an aquifer that (1) supplies any public water system or contains a sufficient groundwater to supply a public water system; (2) contains less than 10,000 mg/L total dissolved solids; and (3) is not an exempted aquifer (35 IAC 730.103). Wells injecting below the lowermost USDW have the least potential for contaminating groundwater. Injection above the aquifer may allow the contaminants to be attenuated or adsorbed, or give them time to degrade in the unsaturated zone. Injection directly into an aquifer will certainly contaminate it (UIPC 1987). Illinois regulations require that injection be above or below the aquifer.

Contamination from Class V wells can result from large-scale events, such as a rain storm hitting farm land just after the application of pesticides so the run-off carries the chemicals into agricultural drainage wells. It can also arise from site-specific events, such as the disposal of household chemicals into a septic system. According to the Groundwater Protection Council, each disposal practice found in Illinois has the potential to contaminate groundwater. This potential for a few well types is summarized below.

Industrial/Commercial/Utility Disposal Wells
Cooling water return flow wells are used to inject water that has been used in a cooling process (both open and closed loop systems). A low to moderate potential for contamination due to anti-sealing additives is likely to be compounded by thermal pollution. Also, there is the potential for industrial spills to reach groundwater. Industrial process water and waste disposal wells have a high potential for contamination because they are used to dispose of a wide variety of wastes and wastewaters from industrial, commercial, or utility processes. Refineries, chemical plants, smelters, pharmaceutical plants, laundromats, and dry cleaners are some of the businesses and industries using these wells. Potential contaminants include fluids discarded by industry, suspended solids, high pH waters, sulfate, and volatile organic compounds. Automobile service station disposal wells receive wastes from repair bays connected to disposal wells; these wells have a high potential for contamination from heavy metals,

Table 16.1. Class V Wells

1.	Mineral and Fossil Fuel Recovery Related Wells	Mining, Sand or Other Backfill Wells Solution Mining Wells In-situ Fossil Fuel Recovery Wells Spent-Brine Return Flow Wells
2.	Industrial/Commercial/Utility Disposal Wells	Cooling Water Return Flow Wells Industrial Process Water and Waste Disposal Wells Automobile Service Station Disposal Wells
3.	Oil Field Waste Disposal Wells	Air Scrubber Waste Disposal Wells Water Softener Regeneration Brine Disposal Wells
4.	Drainage Wells (Dry Wells)	Agricultural Drainage Wells Storm Water Drainage Wells Improved Sinkholes Industrial Drainage Wells Special Drainage Wells
5.	Geothermal Reinjection Wells	Electrical Power Reinjection Wells Direct Heat Reinjection Wells Heat Pump/Air Conditioning Return Flow Wells Groundwater Aquaculture Return Flow Wells
6.	Domestic Wastewater Disposal Wells	Untreated Sewage Waste Disposal Wells Cesspools Septic Systems-undifferentiated disposal method Septic Systems-Well Disposal Method Septic Systems-Drainfield Disposal Method Domestic Wastewater Treatment Plant Effluent Disposal Wells
7.	Recharge Wells	Aquifer Recharge Wells Saline Water Intrusion Barrier Wells Subsidence Control Wells
8.	Miscellaneous Wells	Radioactive Waste Disposal Wells Experimental Technology Wells

solvents, cleaners, used oil and other automotive fluids, and organic compounds.

Drainage Wells (Dry Wells) Agricultural drainage wells receive runoff from irrigation runoff and drainage from animal yards and feedlots; they have a high potential for contamination from pesticides, nutrients, pathogens, metals transported by sediments, and salts from leaching soils. Stormwater drainage wells receive stormwater runoff from paved areas, including parking lots, streets, residential subdivisions, building roofs, and highways; they have a moderate potential for contamination from heavy metals, organics, and coliform bacteria as well as contaminants from streets, roofs, and lawn and garden pesticides.

Geothermal Reinjection Wells Heat pump/air conditioning return flow wells inject shallow wells with the groundwater used to heat or cool a building in a heat pump system. These wells have a low potential for contamination because the water is merely elevated in temperature.

Domestic Wastewater Disposal Wells Untreated sewage waste disposal wells, which receive raw sewage wastes from pumping trucks or other vehicles that collect wastes from single or multiple sources, have a high potential for contamination. Raw sewage not only exposes groundwater to soluble organic and inorganic compounds (such as household chemicals), but also contains pathogenic bacteria and viruses, nitrates, and ammonia.

Miscellaneous Wells The potential for contamination from wells related to aquifer remediation is not known; they are generally used to prevent, control, or remediate aquifer pollution. Contaminants, if present, would include nutrients used in biodegradation of organics, oil/grease, phenols, and toluene (UIPC 1987).

Current Status and the Environmental Implications

The large number of Class V wells injecting a wide variety of contaminants may pose a threat to groundwater in Illinois. The Groundwater Protection Council suggests some types of Class V wells may require stricter regulation than those currently in place. Current Illinois regulations prohibit construction and waste injection into Class V wells without a permit. A standard permit application procedure is used for all UIC wells, but noticeably few criteria and standards in Illinois Admin Code 35 apply specifically to Class V injection wells. It should be noted that the IEPA is returning primacy for this program to the USEPA because the Class V injection program has diverse regulatory needs and is expensive to administer.According to the USEPA Region 5 office, the approach to regulation of these wastes will change from current practice; the new focus will be on waste type, not well type. New regulations are being written in Washington. The USEPA will develop an outreach program to educate industry about these new regulations and ways to meet them. The proposed program will be implemented slowly to give small industry time to comply (C. Anderson, USEPA, personal communication 1993).

As the IEPA and USEPA suggest, the threat from underground injection through Class V wells can be minimized by reduction of waste, recycling, and other good waste disposal practices. Educating well operators and the public is also important. Contamination from disposal into individual septic systems, service station disposal wells, and nonhazardous industrial wells, might be avoided if operators know the risks of improper disposal.

Research Needs The first step toward responsible waste management might be to compile an inventory of all Class V wells in the state or, as proposed by USEPA, only those prone to receiving undesirable types of waste. Currently, wells are entered into the inventory only if a permit is applied for. The IEPA is not actively looking for culpable operators of noninventoried wells, unless a complaint is filed and the well requires remedial action.

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TREATMENT STORAGE AND RECYCLING OF HAZARDOUS AND INDUSTRIAL WASTE

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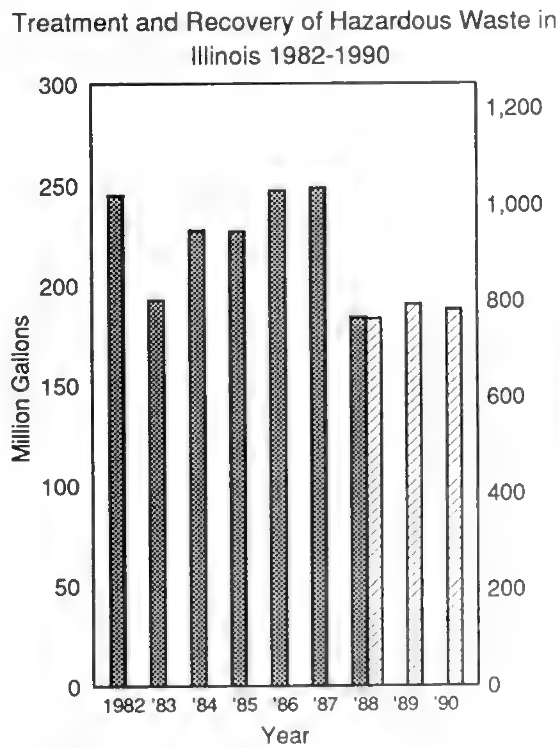
WASTE TREATMENT

Although pollution prevention and waste minimization are emerging as the preferred goals in solving waste management concerns, most industries will still create wastes that require treatment to destroy or reduce their harmful effects on the environment. There are numerous treatment techniques for hazardous and nonhazardous wastes. Many of these techniques are widely used and have gained broad acceptance from government, industry and the public. Combinations of different technologies can be utilized to devise the most cost-effective and environmentally responsible solutions to waste management problems. With careful engineering, integrating treatment technologies directly into the industrial process can also provide a means of minimizing waste (Wentz, 1989).

Reporting requirements for RCRA Subtitle C wastes provide a good basis for determining trends in the types and quantities of hazardous waste treated in Illinois. Beginning in 1983, when state regulations began requiring owners and operators of hazardous waste treatment, storage and disposal facilities (TSDFs) to report the types and quantities of wastes they treated, the State got its first good look at the role of treatment in hazardous waste management practices. Figure 17.1 presents generalized treatment and recovery data collected from annual hazardous waste reports for 1982-1990. Note that the 1990 treatment figure does not include the disproportionately large contribution made by oil refinery wastes that were, up until 1990, not classified as hazardous waste. When the 4,298,160 tons of oil refinery waste are added to the previous 1990 figure, the total for 1990 hits 5,080,644 tons, a 541% increase over 1989 (IEPA/LPC/92-052, 1992).

Classification of treatment and recovery techniques in Figure 17.1 is not specific and changed from year to year. 1982-1984 data were classified under "treatment" only; 1985-1988 data included "treatment and recycling"; 1989-1990 data were reported as "treatment and recovery". As reporting requirements changed over the years, treatment data have become more detailed and complete by including more specific categories: metals recovery, solvent recovery, other recovery, aqueous inorganic treatment, aqueous organic treatment, other treatment, sludge treatment and stabilization. This list excludes incineration, energy recovery (fuel blending), land treatment, landfills, deep well injection, storage, transfer station and disposal. A detailed characterization of the treatment and recovery techniques used in Illinois for hazardous waste was presented in the 1986 TSDR survey compiled by the Research Triangle Institute (RTI).



Source: IEPA Summary of Annual Reports on Hazardous Waste 1982-1990

Figure 17.1

Metals recovery in Illinois commonly includes silver from photographic laboratory waste; lead from various sources (e.g., batteries); chromium and nickel from plating bath waste; and gold and platinum from laboratories and precious-metal working shops (RTI, 1986). The types of metal recovery processes used and the number of facilities in Illinois during 1986 are listed in Table 17.1.

Table 17.1. Metals Recovery for Reuse In Illinois

Total quantity of hazardous waste managed:	
in Illinois (tons)	151,703
% of national total	10
Illinois rank	3
Illinois total recovered (tons)	5,362
Number of:	
Facilities	17
Metals recovery processes	34
Type of metal recovery process:	
Electrolytic	0
Ion exchange	2
Reverse osmosis	0
Solvent extracting	0
Secondary smelting	0
Liming	0
Evaporation	1
Filtration	0
Sodium borohydride	0
Other metals recovery	0
Quantity of residuals generated:	
Total solids (tons)	8
Total liquids	3,049,200
Total sludge residuals	0

Source: RTI, 1986.

Solvent recovery and recycling lessens the demand on higher-priced virgin solvents and helps to reduce VOC emissions into the atmosphere. Solvents may be recovered on- or off-site; many are actually recycled in closed-loop systems where recovery is an integral part of the overall process. The types of solvent recovery technologies and the number of facilities in Illinois during 1986 are presented in Table 17.2. Note that the survey did not include closed-loop solvent recycling in the data.

Aqueous inorganic and organic treatment of hazardous wastewater is usually most efficiently accomplished on-site in either tanks or surface impoundments rather than off-site (Table 17.3). Since most of the waste is water, transportation costs for hauling the wastewater to an off-site treatment facility can be cost-prohibitive.

Solidification or stabilization of hazardous waste sludges and liquids is required before disposal in a landfill. USEPA and state regulations restricting land disposal of liquid wastes have made solidification/stabilization a critical part of the overall hazardous waste management system. Solidification can be accomplished by adding a cement-like mixture to hazardous waste with free liquids. When the solidifying agent hardens, it creates a solid matrix which prevents the migration of hazardous constituents into the surrounding environment or groundwater. One drawback to adding solidification materials to a hazardous waste is that the entire mixture then becomes hazardous and the volume for disposal increases. For 1986 Illinois data, Table 17.4 shows nearly a 40% increase in hazardous wastes that have been solidified (RTI, 1986).

Table 17.2. Solvent and Liquid Organic Recovery for Reuse

Total quantity of hazardous waste managed:	
in Illinois (tons)	102,196
% national total	2
Illinois rank	4
Illinois total recovered (tons)	61,346
Number of:	
Facilities	53
Solvent recovery processes	87
Commercial solvent recovery processes	22
Type of solvent recovery process:	
Fractionation	5
Batch still distillation	25
Solvent extraction	1
Thin-film evaporation	5
Filtration	3
Phase separation (decanting)	5
Desiccation or water removal	0
Other	2
Quantity of residuals generated:	
Total solids (tons)	291
Total liquids (tons)	54,979
Total sludge (tons)	196

Source: RTI, 1986.

Impact of Land Ban Restrictions on Treatment Technologies

Effective in 1992, EPA's restrictions on land disposal of hazardous wastes changed the course of hazardous waste management practices for thousands of industries. Land ban restrictions mandated treatment of certain hazardous wastes prior to disposal in RCRA surface facilities or underground injection wells. According to USEPA Office of Solid Waste,

Table 17.3. Aqueous Inorganic/Organic Treatment

Total quantity of hazardous waste managed:	
in Illinois (tons)	35,849,36
% of national total	5
Illinois rank	5
	8
Number of:	
Facilities	240
Wastewater treatment processes	1,076
Commercial treatment processes	24
Type of unit/process:	
Equalization	49
Cyanide oxidation	24
General oxidation	6
Chemical precipitation	66
Chromium reduction	43
Complexed metals	4
Emulsion breaking	3
Adsorption	11
Stripping	1
Evaporation	4
Filtration	32
Sludge dewatering	75
Air flotation	1
Oil skimming	19
Other liquid phase separation	14
Biological treatment	7
Other wastewater treatment	727

Source: RTI, 1986.

Table 17.4. Solidification/Stabilization

Total hazardous waste managed:	
in Illinois (tons)	126, 234
% of national total	16
Illinois rank	2
Number of:	
Facilities	6
Solidification units	6
Commercial solidification units	2
Type of solidification units:	
Cement or cement/silicate	2
processes	4
Pozzolanic processes	0
Asphalt processes	0
Thermoplastic techniques	0
Organic polymer techniques	0
Jacketing	0
Other	
Volume after solidification, residual (tons):	171,934

Source: RTI, 1986.

the land ban restrictions affected an estimated 32.75 million tons of hazardous waste/year at an estimated cost of $1.49 billion (1990)/year to industry. The land ban rules were aimed at reducing the toxicity or migration potential of hazardous waste prior to land disposal. Wastes not meeting EPA treatment standards for disposal were required to be pretreated using the best demonstrated available technology (BDAT). A list of 26 treatment technologies classified by EPA as BDATs appears in Table 17.5. EPA set standards for BDATs in two forms: concentration-based and technology-based. Concentration standards were based on levels that could be achieved by using a designated BDAT. Any other treatment technology capable of achieving these levels were also acceptable. When data were insufficient to determine a practical concentration level or when a particular treatment technology was found to be the best method to manage a hazardous waste, then a specific BDAT was chosen as a technology-based standard (Turner, 1991).

The cost of treating land ban wastes forces generators to evaluate the economics of on-site vs off-site treatment. The costs of on-site treatment includes permits from state and federal agencies, long-term liability associate with construction and maintenance of a facility, capital investment in process equipment and short- and long-term employee training and health care (Donnachie, 1991). Large quantity generators usually consider on-site treatment to be more cost-effective than shipping waste off-site, but small quantity generators may find on-site treatment cost-prohibitive. Limited financial resources narrow the available waste management options and force small quantity generators to rely on off-site facilities. For small and large quantity generators alike, the high costs associated with treating land ban wastes can be the strongest incentive for finding alternatives to land disposal.

The search for alternatives to land disposal is changing the way waste generators see their overall processes. A strong movement toward waste reduction and pollution prevention is drawing increasing interest from generators looking for innovative solutions to their waste management problems. The development of more effective and efficient technologies for treatment, remediation and waste reduction is one of the primary objectives of the Illinois Hazardous Waste Research and Information Center (HWRIC). Research activities draw upon government, university and industry resources to develop practical technologies for the real world. Recent research efforts tackle recovery of

Table 17.5. Best Demonstrated Available Technologies (BDATs) for Hazardous Waste

1. Aerobic Biological Treatment	14. Hexavalent Chromium Reduction
2. Batch Distillation	15. High Temperature Metals Recovery
3. Carbon Adsorption	16. Ion Exchange
4. Critical Fluid Extraction	17. Retorting
5. Fractionation	18. Stabilization of Metals
6. Fuel Substitution	19. Chemical Oxidation
7. Incineration	20. Polishing-Filtration
8. Solvent Extraction	21. Sludge Filtration
9. Steam Stripping	22. Thermal Drying
10. Thin Film Evaporation	23. Wet Air Oxidation
11. Acid Leaching	24. Vitrification
12. Chemical Precipitation	25. Encapsulation
13. Electrolytic Oxidation (Cyanide)	26. Chemical Reaction

Source: USEPA, 1990

electroplating rinsewater through reverse osmosis and low temperature evaporation; recovery of aqueous cleaners and die lubricants by ultrafiltration; treatment of refinery sludge with emulsification and oil/water separation; and stabilization of VOC contaminated soil by vitrification. HWRIC is working to overcome barriers to developing alternative technologies in order to meet the changing needs of waste generators and to successfully implement them in the real world.

A study done by the Illinois Hazardous Waste Advisory Council sites generator attitudes, economic concerns and regulatory red-tape as the greatest barriers to the use of alternative technologies. The attitudes of waste generators reflect a reluctance to change from operations personnel and a lack of knowledge about waste reduction techniques. In this rapidly changing regulatory climate, generators fear performance of alternative technologies today will soon fall short of regulatory standards tomorrow. Developers of off-site treatment facilities are also apprehensive about investing a lot of time and money in a facility design only to have the local community reject the proposal. Economic concerns arise from the difficulty to accurately quantify long-term benefits over short-term costs. Small quantity generators are sharply limited in their economic resources and may not be able to afford equipment for on-site treatment or process changes to reduce waste. As long as land disposal is simpler and less expensive, little incentive exists to consider alternative technologies. Regulatory red-tape creates another barrier to the use of alternative technologies because of the time, expense and complexity involved in applying for permits. Even generators who make changes in their process to reduce waste may be required to obtain environmental permits. Delisting treatment residuals that no longer exhibit hazardous characteristics can also be a costly and lengthy process (Illinois Hazardous Waste Advisory Council, 1986).

Chemical Treatment

Chemical treatment relies on chemical reactions to alter a waste's properties and facilitate in-process recycling or safer disposal. Chemical treatment can be used to achieve compliance for wastewater discharge or stabilization for land disposal. Depending on the waste stream, chemical treatment can also be employed in waste reduction or resource recovery of valuable raw materials (Wentz, 1989).

There are many different types of chemical waste treatment, and each may require a variety of chemicals and special equipment. Some of the principal chemical processes used in chemical waste treatment include neutralization, precipitation, coagulation and flocculation, oxidation and reduction, ion exchange and solidification. In some cases, the chemical treatment method may increase the volume of waste for disposal in exchange for reducing its hazardous characteristics (Wentz, 1989).

Physical Treatment

Physical treatment involves a variety of separation techniques designed to reduce the volume of waste and potentially recover reusable raw materials. Physical treatment won't destroy toxic components, but it is capable of removing some hazardous constituents from waste through physical separation (Members of the Hazardous Waste Dialogue Group, 1983). Unlike chemical treatment, physical treatment doesn't require a stockpile of chemicals and won't increase the volume of waste for disposal.

Physical separation processes include screening, sedimentation and clarification, centrifugation, flotation, filtration, sorption, evaporation and distillation, stripping and reverse osmosis. These processes take advantage of differences in physical size, density, solubility and boiling point of the components in the waste stream to facilitate separation. The requirements for the treated effluent are an important criteria in the selection of the most cost-effective method (Wentz, 1983).

Thermal Treatment

Thermal destruction of hazardous wastes can be effectively accomplished through incineration. Incineration is the controlled burning of waste at temperatures high enough to oxidize organic compounds to produce carbon dioxide and water. Additional inorganic substances are also produced in the incineration process, such as acids, salts, metallic compounds and ash. To effectively use incineration to destroy hazardous wastes requires a thorough understanding of the chemistry and design behind the process. The degree of destruction depends on turbulence, temperature and time in the combustion chamber, so operating conditions must be selected carefully. The rate of destruction and removal efficiency are determined during a test burn by monitoring exhaust gases and ash content (Wentz, 1989).

Biological Treatment

Biological treatment can be an efficient, cost-effective means to remove hazardous constituents from contaminated wastewater and groundwater, landfill leachate and contaminated soil. Microorganisms are used to feed on the waste and biodegrade the hazardous components. Many people think that hazardous waste would be toxic and deadly to microorganisms, and for certain microorganisms this is true. However, what may be toxic to one group of organisms could be a valuable food source for another microbial strain. Biological treatment systems are designed by selecting the proper distribution of microorganisms and the most favorable operating conditions to do the job. With the right lighting, nutrients, temperature, pH and oxygen supply, the microorganisms can thrive on the waste and convert the hazardous constituents into harmless gas, water and a biological sludge which may or may not be hazardous. Common methods for biological treatment include aerated lagoons, trickling filters, rotating biological contactors and anaerobic bioreactors (Wentz, 1989).

WASTE STORAGE

Waste is reported as stored for several reasons, including:

1) waste in long-term storage on the site of generation (primarily in waste piles and surface impoundments);

2) waste stored at transfer stations for accumulation and regularly shipped elsewhere for further treatment/recycling;

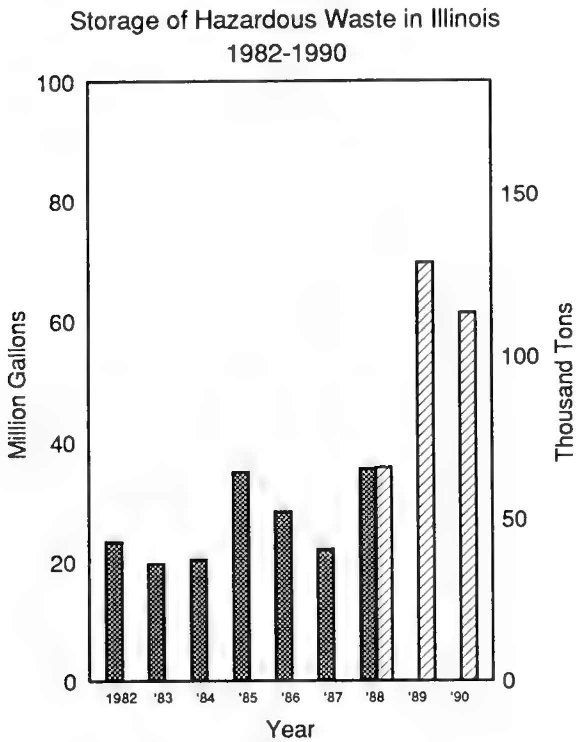
3) waste in storage for a portion of the year at the site of generation that is later shipped off-site for treatment, reclamation, or disposal; and

4) waste generated during a given year, placed in storage and still in storage at the end of the calendar year (IEPA/LPC/92-052, 1992).

Industry considers storage as one of the most common and least costly methods of handling wastes when treatment or disposal is not a cost-effective option. However, the Illinois Department of Energy and Natural Resources (DENR) sees long-term storage of waste among the least preferable of management options from an environmental standpoint (Heavisides, 1983). DENR's concerns over the environmental integrity of these long-term storage practices stem from past reports of wastes leaking into ground and surface waters and incidents of fires and explosions occurring with ignitable or highly reactive wastes (Members of the Hazardous Waste Dialogue Group, 1983).

New regulations are cracking down on careless storage practices and changing the way facilities do business. Today storage facilities must comply with Illinois operating standards which include obtaining hazardous waste identification numbers, conducting detailed chemical and physical analysis of waste received, maintaining adequate site security and following certain facility inspection procedures. Generators who store hazardous wastes on site for a limited period (usually less than 90 days) may be exempt from storage permit requirements but must still comply with basic storage regulations. Illinois requires such generators to certify that containers and tanks are not leaking; that design specifications are met for strength, thickness and chemical compatibility; and that provisions are made for accidental releases (Attorneys of Sidley and Austin, 1989).

Typical storage practices utilized by industry include surface impoundments for liquid wastes, waste piles for solid or containerized materials and containers and tanks for above and below ground storage (Heavisides, 1983). Figure 17.2 shows the total quantity of hazardous waste stored in Illinois for 1982-1990.



Source: IEPA Summary of Annual Repots on Hazardous Waste 1982-1990

Figure 17.2

Surface impoundments are typically ponds or lagoons used to store, treat, and/or dispose of large quantities of liquid waste. Those dedicated to storage are used to collect and hold waste until it can be treated or disposed. Sometimes storage and treatment can even take place in the same surface impoundment (RTI, 1986). Many old, unlined impoundments were considered by DENR as probably the most significant source of chemical pollution in Illinois groundwater (Heavisides, 1983). This concern over groundwater contamination prompted stricter technical requirements for surface impoundments. In order for existing surface impoundments to remain operational, facilities were required to install double liners, leachate collection and groundwater monitoring by November 1988. Because of the expense in retrofitting old surface impoundments, many facilities chose to close down (USEPA, SWER, 1991). In 1983, IEPA estimated that there were as many as 150 on-site storage impoundments in Illinois in the state (Heavisides, 1983). Three years later, a 1986 survey counted only 27 surface impoundments holding over 60% of the hazardous waste stored, a dramatic decline from 150 (RTI, 1986). The closing of these old surface impoundments was expected to temporarily increase the quantity of hazardous waste managed due to contaminated soils removed by dredging (USEPA, SWER, 1991). Table 17.6 sites data from the 1986 RTI survey for hazardous waste surface impoundments in Illinois.

Table 17.6. Hazardous Waste Surface Impoundments

Total quantity of hazardous waste managed:	
Illinois (tons)	5,385,751
% of national total	2
Number of:	
Facilities	12
Surface impoundments	27
Commercial Surface impoundments	0
Type of unit/process:	
Treatment impoundments	17
Storage impoundments	12
Disposal impoundments	1
Type of flow:	
Flow-through	22
Other	5
Type of liner:	
Double liner	0
Single liner:	
Synthetic	3
Clay	12
Composite	7
Other	5

Source: RTI, 1986.

Waste piles rank second behind surface impoundments, accounting for nearly 30% of the hazardous waste stored in Illinois. Waste piles are essentially unconstructed piles of solid waste or waste-filled containers used for storage. Under current USEPA regulations, RCRA hazardous waste piles have become subject to land disposal restrictions. This has resulted in the closing of many waste piles as hazardous waste management units, often being replaced by covered tanks or container storage (RTI, 1986). Table 17.7 presents information from the 1986 RTI survey of hazardous waste piles in Illinois.

Table 17.7. Hazardous Waste Piles

Total quantity of hazardous waste managed:	
Illinois total (tons)	13,838
% of national total	2
Number of:	
Facilities	2
Waste piles	5
Commercial waste piles	0
Type of liner:	
Double liner	0
Single liner	0
Concrete pad	3
Other	2

Source: RTI, 1986.

Tanks and containers are used to store roughly 5% of the hazardous waste managed in Illinois.
Tanks are stationary devices whereas containers are movable. Management units considered to be tanks may include equalization tanks, holding tanks, clarifiers, filter presses, blending tanks, distillation towers, accumulation/storage tanks, sumps and treatment tanks. Tanks may be located on the ground or a concrete foundation, elevated above ground, buried under ground, or built in ground. In-ground tanks may be large and concrete-lined with open tops, resembling surface impoundments, but are defined as tanks because they are structurally self-supporting. Illinois specific data on tank systems is available from the 1986 RTI survey and is summarized in Table 17.8.

Table 17.8. Tank Systems for Hazardous Waste Storage

Number of:	
Facilities	396
Tanks	2,236
Relationship of tank to ground:	
Totally above grounds (elevated or cradled)	705
On the ground or concrete foundation	838
In ground	189
Completely below ground	107
Other	397
Secondary containment:	
Double-wall tank	41
Vault (e.g. concrete)	143
Berm or dike around tank	648
Liner under the tank	103
No secondary containment	911
Other	213

Source: RTI, 1986.

In the *1990 National Water Quality Inventory*, underground storage tanks (USTs) were considered by far the most important and most frequently ranked groundwater contamination source by 56 states and territories polled (Ground Water Monitor, March 24, 1992). The number of USTs in the United States containing petroleum or hazardous chemicals is estimated at 1.7 million (USEPA, OUST, 1992). In 1984, Subtitle I was added to the Resource Conservation and Recovery Act (RCRA) requiring the EPA to develop regulations to prevent, detect and correct leaks from USTs while making sure UST owners and operators could pay for remedial action. The LUST Trust Fund was created in 1986 from taxes on gasoline to provide states with financial assistance to clean up abandoned or mismanaged leaking USTs (LUSTs) (LUST Line, February 1990). Illinois draws additional money for UST activities from a variety of other sources. Regulatory programs are funded by site activity fees for installation and closure and by an annual fee for tank testers. Cleanup activities are funded in part by a $500 one-time tank registration fee and by a $100 annual fee for all owners and operators (LUST Line, May 1988).

According to USEPA, as of July 1992, over 160,000 releases were reported; over 110,000 corrective actions had been initiated; and over 45,000 corrective actions had been completed nationwide (LUST Line, October 1992). Within the past three years, more than 25 percent of tank operations have closed because of inabilities to meet new or upgraded tank performance standards (USEPA, OUST, 1992).

RECYCLING

Recycling and recovery have become important means to reduce the volume of hazardous waste generated by industrial facilities. Generally speaking, recycling and recovery is more expensive than the reduction of waste at the source. Nonetheless, industrial facilities have found recycling and recovery to be viable alternatives to the disposal of hazardous or special wastes.

Recycling of hazardous or industrial wastes involves using waste streams as raw materials in industrial or chemical processes. Recovery refers to the extraction of usable raw materials from a waste. The wastes having the greatest potential for recovery include organic liquid wastes from which solvents may be extracted, industrial sludges and metal plating wastes from which metals can be recovered. Both recycling

Table 17.9. Industrial Materials Exchange Service - 10 Year Assessment
1981 - 1990

Year	Listings	Transfers	Cost Savings (thousands)	Qty. Transferred (thousand gallons)
1981-1982	138	29	$ 442	690
1983	162	25	$ 510	4,250
1984	211	43	$ 1,213	944
1985	335	69	$ 7,056	3,525
1986	600	74	$ 7,209	16,972
1987	429	40	$ 4,516	5,314
1988	382	43	$ 2,114	2,573
1989	483	79	$ 4,401	10,335
1990	476	101	$ 10,746	10,076
1991	486	98	$ 13,092	7,620

and recovery are effective in reducing the amount of waste generated and ultimately, the amount of waste requiring disposal.

Among the efforts to encourage recycling in Illinois, a success may be found in IMES, the Industrial Material Exchange Service (IMES), founded in 1981. This service is cosponsored by the Illinois EPA and the Illinois State Chamber of Commerce and seeks recycling markets for industries' reusable materials. A bi-monthly directory is published listing potentially recoverable materials available from or wanted by industry. IMES acts like a clearinghouse and marketing facilitator for both hazardous and nonhazardous by-products that might otherwise be wasted. During the past ten years IMES has helped to divert over 54.7 million gallons of industrial material from landfill disposal.

Companies with materials that are not usable at their facility but are potentially useful to others are able to market these materials through IMES. Companies that have the capability to use wastes, surplus or recoverable materials can find them using the IMES directory. Information is submitted to the IMES directory free-of-charge, published and mailed to over 13,000 subscribers nationwide. Information from IMES is also available on the National Waste Exchange On-Line Database providing access to a wider audience.

During 1991, the IMES directory had 486 listings which resulted in 98 completed transfers of materials (some transfers were in the negotiation process at the time this information was available). These transfers resulted in over $13 million in cost saving to industry and diverted over 7 million gallons (or gallon equivalents) of materials from landfill disposal.

As environmental regulations become more comprehensive and costs of disposal rise, one would expect services such as IMES to be increasingly in demand. Since its first year of operation, IMES has increased the number of directory listings from 138 in 1981/1982 to 486 in 1991. Likewise, the quantity diverted from landfill disposal has increased as well. Table 17.9 lists a ten-year assessment provided by IMES summarizing the use of the service.

As of March 1993, 18 facilities in Illinois were permitted for recovery of hazardous and industrial wastes (not including fuel blending facilities). Activities conducted by these facilities include recovery of solvents, recycling of oils and fuels and the recovery of metals (precious and non-precious). Table 17.10 lists the type of recovery activity and the number of permitted facilities in the state.

The quantity of waste recovered in Illinois is difficult to determine. Changes in the annual reporting system for hazardous wastes make current information incomparable to some previous years. During the

Table 17.10. Number of Recovery Facilities in Illinois by Type

Number	Recovery Type
6	Solvents
5	Oils/Fuels
3	Metals (not including precious metals)
5	Precious Metals

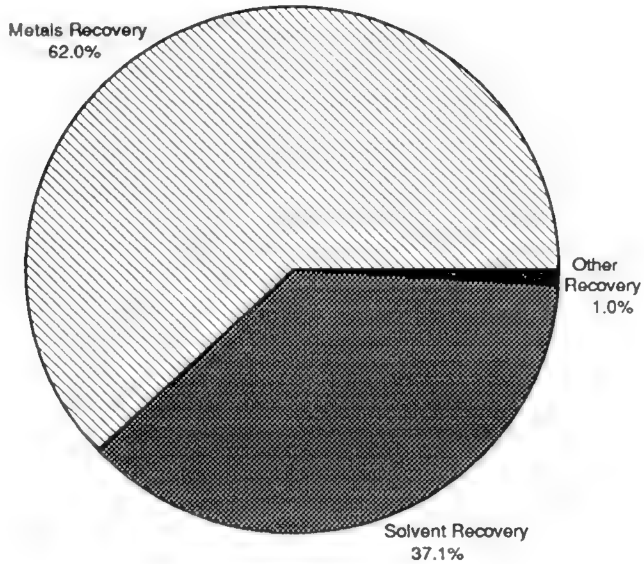
Source: IEPA personal communication.

1990 reporting year, over 41 million gallons of hazardous waste were managed by recovery. For 1989 it was estimated that approximately 35 million gallons of hazardous waste were managed with a recovery process. A study conducted by Research Triangle Institute evaluated solvent recovery and metals recovery practices during 1986. Using a survey of hazardous management facilities, it was estimated that over 250,000 tons of wastes were managed by solvent or metals recovery by 70 facilities. The survey included both commercial TSDR facilities and generators that manage some of their wastes on-site which may account for the larger number of facilities reported in 1986 than 1990.

During 1989 and 1990, metals recovery was used as a management technique more often than solvent recovery. Figure 17.3 displays the relative percentage of hazardous wastes managed with metals, solvents and other recovery in 1990.

One would expect that the quantity of waste recycled or recovered in the state will continue to increase as the costs of disposal rise and capacity for disposal decreases.

1990 Hazardous Waste Recovery in Illinois



Source: IEPA Annual Report on Hazardous Waste 1990

Figure 17.3

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POLLUTION PREVENTION

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The current trend toward pollution prevention as a complement to environmental regulation has a number of positive consequences for industry and the environment. Firms adopting a pollution prevention strategy benefit by reducing costs, improving product yield and providing safer working conditions. Lower waste disposal expenses and raw material costs result if a waste is no longer generated or if materials can be reused or recycled. In some cases, insurance premiums have been reduced for firms handling less toxic materials. A pollution prevention strategy can reduce potentially harmful discharges and releases to the environment and can help conserve natural resources. The adoption of the federal Pollution Prevention Act of 1990 and the Illinois Toxic Pollution Prevention Act of 1989 makes preventing pollution at the source an important objective of federal and state environmental regulation. The concept of mutually protecting the environment and fostering economic growth will be a common theme into the next century.

Successful pollution prevention programs must have the support and commitment of top level management who have the power to make decisions to change "business as usual". Pollution prevention projects include process modifications, installation of more efficient equipment, substitution of safer or less toxic raw materials, in-process or on-site recycling or improved housekeeping. Waste reduction is also possible by working with suppliers to develop alternative raw materials or delivery schedules. This discussion presents a few examples of the many successful pollution prevention projects undertaken by Illinois companies.

Some pollution prevention projects modify a process to use less raw material and reduce waste volume or recover components for reuse. With the assistance of HWRIC's pollution prevention team, metal fabricator R.B. White, Bloomington, dramatically cut waste disposal costs with such a process modification. Prior to using the ultrafiltration system, R.B. White disposed 15,000 gallons of bath solution a year as a hazardous waste. An ultrafiltration system was added to R.B. White's process to clean an oil contaminated degreasing/phosphating bath. The ultrafiltration process modification reduced the generation of this hazardous waste by 99.8% to approximately 30 gallons per year at an annual cost savings of almost $20,000.

Illinois electronic equipment manufacturers Motorola, in Schaumburg, and Harris Corporation, in Quincy, modified processes by eliminating a cleaning step in circuit board assembly. Motorola adopted a no-clean soldering technology and a spray fluxing process. This modification saved production time, reduced equipment maintenance and eliminated the release of chlorofluorocarbons (CFCs) and volatile organic compounds (VOCs). As a result, the Motorola Cellular Subscribers Group saved over $100,000 per year in solvent purchases. Harris Corporation, a television transmitter manufacturer, began using a water-clean solder, eliminating a cleaning step requiring methyl chloroform (TCA), an ozone depleter. Harris saved $4,500 per year in raw material costs and eliminated the cost of TCA disposal.

Investing in more efficient and updated equipment is another way that Illinois companies have successfully reduced waste and pollution. At Viskase Corporation's Bedford Park plant, carbon disulfide emissions were reduced by 12% per pound of product in part by the implementation of a new unloading and storage system for carbon disulfide. The new, totally enclosed nitrogen system eliminated about 5,000 pounds per year of carbon disulfide releases to the environment which would otherwise have occurred using their old water system. A recently upgraded evaporator and system modifications at Viskase reduced ammonium sulfate (solution) releases by about 300,000 lbs/year. Adjusting for production, this represents a 35% reduction in release of ammonium sulfate (solution) to the environment.

Illinois metal products fabricators have found powder coating equipment to be more efficient than traditional painting or coating processes which generate hazardous paint sludges and VOC emissions from overspray and solvents. Eaton Corporation, Lincoln, replaced a liquid paint dip system with an electrostatic powder coating process. The new system allows all excess coating material to be reused; the liquid dip system produced a heavy-metal paint sludge which could not be reused in the process and required handling as a hazardous waste. Adopting the more efficient technology eliminated all of the waste associated with Eaton's liquid system and reduced VOC emissions by over 69,000 pounds. The Marvel Group, a Chicago manufacturer of office equipment, found the adoption of a powder-coating process saved 120,000 pounds of paint sludge waste and reduced VOC emissions by 64%.

Raw material substitution is a common pollution prevention technique used successfully to reduce environmental releases. Firms have replaced chlorinated solvents with non-chlorinated substitutes. Caterpillar's Peoria Plant significantly reduced trichloroethane, trichloroethylene and freon 113 release as the result of waste reduction efforts. National Castings, a Melrose Park steel foundry, replaced two 1,1,1-trichloroethane-based products in their sand core coating process with a water-based product. Viskase eliminated about 32,000 pounds per year of chlorinated solvents by substituting nonhazardous aqueous based degreasers. By substituting alcohol-based inks and cleaning agents with aqueous inks and cleaners, MPI Label Systems reduced in-plant solvent emissions by 80%. Much of their hazardous liquid wastes were eliminated saving $15,000 on waste disposal. The University of Illinois Printing Office has substituted soy inks for petroleum-based inks with no major process modifications. Soy inks are less volatile than petroleum inks and require 15% less ink for equivalent quality production.

Illinois companies have found many opportunities to recycle by-products that had previously been discarded as hazardous wastes or sent to landfills. The Caterpillar facility in East Peoria has not disposed paint sludge since 1989 due to a dewatering process allowing the sludge to be recycled into various paints or other products.

DAP, Inc., an adhesive and caulk manufacturer in Rosemont, implemented a novel process to reuse solvents. Previously, solvent waste was generated when mixers were cleaned between batches. Since different vehicle solvents are required for the production of adhesives with different specifications, the equipment requires cleaning after each different batch. DAP now cleans the mixer with the same vehicle solvent required for a particular batch. Rather than discard the cleaning solvents, the material is now drummed and saved until a batch of the same product is manufactured. It is then used as the vehicle solvent in the production process for the new batch. This in-process recycling system resulted in yearly savings of over $40,000 due to lower disposal and raw material costs.

An in-process recycling system was established by Eagle Wings Industries, a Rantoul manufacturing firm that supplies steel component parts to the automotive industry. A surface treatment process, required prior to painting, resulted in a zinc phosphate solution previously disposed to the wastewater treatment system. By filtering this solution, Eagle Wings removed phosphate sludge and was then able to reuse the solution in the surface treating process. This reuse diverted over 38,000 gallons per year of solution from the wastewater treatment system and resulted in a yearly savings of nearly $7,000 in raw material and labor costs.

Caterpillar has also found success with recycling of dunnage (paper, cardboard, plastic, wood, wood pallets and other garbage). Materials found in dunnage that can be recycled are sorted out of shipments going to landfill disposal and recycled. Caterpillar reduced the volume of dunnage being shipped to landfills from almost 80,000 cy in 1988 to less than 30,000 cy in 1992.

Paul's Machine and Welding Corporation in Villa Grove, a manufacturer of industrial machinery and farm equipment, recently took its first step in pollution prevention by making simple housekeeping and process changes. The most productive change involved reducing the thickness of plastic sheets used to catch paint drippings and the frequency with which they were replaced. The company reduced it's volume of paint related hazardous waste and associated disposal cost by approximately 50 percent. The change also reduced supply and labor costs. No investment was required on the part of the company to achieve these results aside from an awareness of how small changes in practices can impact pollution.

CCL Custom Manufacturing, a Danville contract packager of liquids and aerosols, greatly reduced wasted raw materials and products by inspecting all process lines and pumps in the facility. Through this procedure, they identified leaks and other housekeeping and maintenance problems that could be easily repaired. The implementation of an employee awareness program helped identify recycling opportunities for waste cans. These activities at CCL Custom Manufacturing, along with process modifications, resulted in a cost savings of over $600,000 for the facility.

The potential to work with suppliers to develop less toxic raw materials or reduce waste is a useful pollution prevention alternative. Griffin Wheel Company, in West Chicago, a manufacturer of railroad brake shoes, used toluene in the manufacturing process to lower the viscosity of resins and soften the rubber component of the binding material. With the help of their supplier, Griffin reformulated the resin so the addition of toluene was no longer necessary. A new mixer was purchased that further reduced the need for toluene. By working with their supplier and implementing new technology, Griffin eliminated the need for nearly two million pounds of toluene per year. They also reduced toluene emissions from 2 to 4 hundred thousand pounds per year to zero. In cooperation with their paint supplier, the Interlakes Companies, Pontiac, eliminated the heavy metals lead and chrome from their paint while maintaining a high quality finish. This change in material reduced disposal costs and improved worker safety by reducing the hazard level of the waste.

Selling and purchasing raw materials in bulk has also allowed many companies to reduce waste. Nalco Chemical Company, of Naperville, a specialty chemical manufacturer, provides products to their customers in returnable, reusable containers. The containers hold a larger volume of chemical than the drums used previously, require less frequent delivery and eliminate the customers responsibility for container disposal and remaining residue. The disposal of over one million drums and one millions gallons of residue has been eliminated nationwide since 1984 with the use of Nalco's reusable containers.

As awareness of pollution prevention opportunities increases, Illinois companies will find such projects a cost-effective way to address environmental concerns.

REMEDIATION

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More than 6 billion tons of municipal and industrial waste - nearly 50,000 pounds per person - is produced annually in the United States. Even if production of wastes was instantly reduced to zero, past disposal practices will ensure for several decades that many Americans are exposed to the effects of these wastes. The General Accounting Office (GAO, 1987, p. 13) estimates that on the basis of USEPA and other federal agency data, there may be 130,300 to 425,400 potential hazardous waste sites in the United States that qualify for inclusion in the federal inventory (CERCLIS). Table 19.1 lists the number and type of remediation sites in Illinois as of 1990 (IEPA, 1990). In addition to these almost 1,500 sites that are to be cleaned up, there are numerous other sites still needing to be investigated.

Table 19.1. Number of Remediation Sites in Illinois

Potential Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or Superfund)	1,360
State Remedial Action Priorities List	37
National Priorities List (Listed and Proposed)	38
Immediate Removals	49
Total	1,484

Source: IEPA, 1990.

The types and number of potential hazardous waste sites in the United States is difficult to ascertain. Gross estimates from 1987 put the total number of sites nationwide between 130,000 and 425,000 (Table 19.2). New sites are continuously being discovered, investigated, and added to this list both for immediate removal action to lessen the threat to health and safety and for long term remediation. Many different types of activities have resulted in environmental contamination. These activities include waste disposal, spills and leaks from chemical storage, pesticide mixing, mining, recycling, past energy generation, and wood preservation.

The main concern with these waste sites is that humans can be exposed to hazardous substances released from waste disposal and industrial sites through direct contact with contaminated air, soil and waste; and through indirect exposure from contaminated food chains of aquatic and terrestrial biota. A recent USEPA survey found that more than 40 million people live within four miles, and about 4 million within one mile of a toxic or hazardous waste site. In spite of the large numbers of people potentially at risk, epidemiological data that identifies and quantifies any adverse effects associated with residential exposure to hazardous waste sites is lacking.

Approximately 25 epidemiological studies have examined the residential health effects associated with hazardous waste sites; most have been carried out in the past decade (NRC, 1991). Few of these studies have attempted to measure personal exposure levels but have relied on measures such as:

1) distance from the site and/or duration of residence;

2) quantified surrogates of exposure such as estimates of drinking water use, or;

3) quantified area or ambient measurements in the vicinity of the residence or other sites of activity.

Use of surrogate exposure measures can place individuals in incorrect exposure categories, and such misclassification generally weakens the association between exposure and outcome (NRC, 1991, p. 130).

THE LEGISLATION

In the early-1970s, the country was discovering such notorious dump sites as Love Canal (New York) and the Valley of the Drums. Illinois had similar sites in towns such as Wilsonville, Sheffield, and Granite City, which eventually gained national attention. Even though the public was very concerned, there was no epidemiological data proving the risks or threat that hazardous waste sites posed to humans. In the mid-seventies Congress enacted two major pieces of legislation to control the production and distribution of hazardous wastes, and to minimize exposure through cleanup of abandoned sites. The beginning of federal waste regulation came in 1976 with the enactment of RCRA (Quarles, 1990), the

Table 19.2. Types and Estimated Numbers of Potential Hazardous Waste Sites in the United States.

Type of site	U.S. 1987[1]
Waste Facilities: Nonhazardous (RCRA subtitle D) Hazardous (RCRA subtitle C)[2]	 70,419-261,930 818[3]
Mining Waste Sites	22,339
Underground Storage Tanks (Non-petroleum)	10,820
Pesticide-contaminated Sites	3,920[4]
Federal Facility Sites: Civilian Defense	 1,882 3,526
Radioactive Releases	300
Underground Injection Wells	13,839-117,368
Town Gas Facilities	1,502
Wood Preserving Plants	975
Total	130,340-425,380

[1]Estimates include an unknown number of CERCLIS sites.
[2]Projected failures of facilities under RCRA financial assurance requirements.
[3]Includes 171 municipal landfills or dumps that may also be included in the estimates of RCRA subtitle D facilities.
[4]Number of sites in six states where pesticide levels exceed state standards.

Source: GAO, 1987.

Resource Conservation and Recovery Act.

The USEPA proposed the first set of regulations implementing RCRA in December 1978, the regulatory framework was promulgated in May 1980, and the regulations became effective in November 1980. RCRA implements a comprehensive regulatory program for managing hazardous waste, from its generation to its disposal. Three types of hazardous waste facilities are subject to waste management and site closure regulations: land disposal, incinerator, and treatment and storage facilities. As of February 1991, 4,615 hazardous waste facilities were subject to RCRA requirements (GAO, 1991, p. 8).

In 1980, Congress enacted companion legislation, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; P.L. 96-510), commonly known as Superfund. This law established a national program for the identification, assessment, and cleanup of abandoned hazardous waste sites, as part of the USEPA. The goals of the bill included establishment of an inventory of inactive hazardous waste sites in a systematic manner, establishment of priorities among the sites based on relative danger, a response program to contain dangerous releases from inactive hazardous wastes sites, and a systematic program of funding to identify, evaluate and take responsive actions at inactive hazardous waste sites to assure protection of public health and the environment in a cost-effective manner.

Thus, Congress wanted to know how much environmental contamination has been caused by hazardous waste sites and to ensure that the sites presenting the worst public health problems would be dealt with first. The legislation created a new public health agency to deal with the human health effects of hazardous wastes, the Agency for Toxic Substances and Disease Registry (ATSDR), within the U.S. Public Health Service. The actual health risks to communities living around a hazardous waste site were to be identified, so that the information could be used in making decisions about remediation. Congressional intent was that remediation programs would do the most possible, within resource constraints, to protect the health of the public.

ATSDR was authorized by CERCLA in 1980 but it was not established until 1983, following a lawsuit by the Environmental Defense Fund, the Chemical Manufacturers Association and the American Petroleum Institute (Siegel, 1990). Given this late start, ATSDR had accomplished very little measurable work on the health aspects of hazardous waste sites by the time Superfund was due for reauthorization in 1985.

Congress attempted to correct the problems with USEPA's site evaluation process and ATSDR's failures in the Superfund Amendments and Reauthorization Act in 1986 (SARA; P.L. 99-499). EPA was directed to revise its site evaluation process and ATSDR was directed to produce public health assessments of all Superfund sites for the National Priorities List (NPL) established by the USEPA, and for other sites in response to public petition. ATSDR also was required to establish a priority list of hazardous substances found at CERCLA sites, to produce toxicologic profiles for each substance on this list, and to carry out research on the health effects of hazardous substances and hazardous waste sites. ATSDR's health assessments affect both USEPA's decision to list a site on the NPL and the remediation goals and methodologies.

Site assessment is accomplished as follows. In the *preremedial process*, a preliminary assessment (PA) and site inspection (SI; of some sites) are carried out, and a preliminary hazard ranking system score (HRS; a value between 1 and 100) is computed using several types of data. The PA is a review of existing information on chemicals present at the site and on potential releases. If the HRS is high enough, the site will be proposed for the NPL and will go on to the remedial process. Until 1992 in Illinois, some sites not ranked high enough for listing on the NPL were placed on the State Remedial Action Priorities List (SRAPL). In December 1992 a court order declared void the rule establishing the SRAPL. As a result, this program no longer exists. Revisions to the State Contingency Plan will be necessary to establish a new program. The *remedial process* includes the remedial investigation/feasibility study (RI/FS), project scoping, site characterization, and development of remedial action objectives. This process is followed by the *development and screening of alternatives*, which includes development of a record of decision (ROD), remedial design (RD) plan for engineering and construction of the chosen remedy, and remedial action (RA) to implement the remedial strategies.

THE NATIONAL PICTURE

Under the National Contingency Plan (NCP) developed by the USEPA to implement CERCLA, more than 31,000 sites have reported to the CERCLA Information System (CERCLIS) inventory of sites that potentially require cleanup. The USEPA has completed more than 27,000 preliminary assessments and has carried out detailed investigation of over 9,000 sites. As of March 1991, 1,189 sites were on the final NPL. USEPA's Region V office (including Illinois) compared Hazard Ranking System (HRS) scores after a site investigation (SI), and found both false positives and false negatives. Only 30 percent of sites with high projected scores (placing them on the NPL) actually ended up with scores above the Superfund threshold, and 10 percent of the sites with low priority projections ultimately received HRS scores above the Superfund threshold for NPL ranking[2] (NCR, 1991, p. 80).

SARA impacted both the time frames and costs associated with the Superfund process. At the time SARA was initiated, USEPA staff projected a 9-month increase in the time it takes to handle a Superfund cleanup; that is, from 58 months to 67 months. The remedial investigation/feasibility study (RI/FS) work plan is supposed to be developed within 6 months of the commencement of discussions with cooperative potentially responsible parties (PRPs). The RI/FS itself will take another 18 months. The health assessment should be available toward the end of the second year. Public and state comment will occur in the third year, after which the record of decision (ROD) is prepared. The remedial design will be available around the end of the third year, and the consent decrees may be entered at any time there is a settlement. Thereafter, review and contracting will occupy most of the fourth year. Remedial action, which takes an average of 2.5 years, will bring USEPA's estimate of the total elapsed time to over 6.5 years; that is, the remedy is even further away (Hellman and Hawkins, 1988, p. 99).

Table 19.3 gives the actual times for sites to reach points in the Superfund process, as found by a 1988 Office of Technology Assessment (OTA) case study of Superfund cleanups. As an example in Illinois (IEPA, 1989, p. 18), between 1946 and the mid-1960s, Sangamon Electric Co. operated a two or three acre landfill near, and draining into Crab Orchard Lake, in the Crab Orchard National Refuge in Jackson and Marion counties near Carbondale. Soil samples collected at the edge of the landfill had polychlorinated biphenyls (PCBs) in the range of

Table 19.3. Time for Sites to Reach Points in the Superfund Process

	Average	Range
From Entry into Superfund Until:		
Preliminary Assessment (PA) Completion	18 months	1-45
Site Inspection (SI) Completion	21 months	1-44
Placement on National Priorities List	36 months	4-75
Start of RI/FS	44 months	20-68
Completion of RI/FS	75 months	47-103
Signing of ROD	81 months	50-104
Completion of ROD Remedy (estimated)	10 years	6-20
From Preliminary Assessment Completion Until:		
Site Inspection (SI)	14 months	0-39
Placement on NPL	32 months	3-73
Start of RI/FS	42 months	13-68
Between Placement on NPL and Start of RI/FS	16 months	3-39
Duration of RI/FS:		
Studies	32 months	21-38
Total Period (studies through ROD)	34 months	24-39
Between Signing of ROD and ROD Estimate of Completion of Remedial Action	38 months	20-120
Duration of Public Comment Period	33 days	24-44
Time Between End of Public Comment Period and Signing of ROD	34 days	15-122

Source: OTA, 1988.

12,000 ppm, and lead in the range of 7,000 ppm. The U.S. Fish and Wildlife Service (the federal owner of Crab Orchard Refuge is the U.S. Department of the Interior) and Sangamon/Westin (the successor to Sangamon Electric) completed a remedial investigation during the Fall of 1988. Seven out of 28 sites included in the remedial investigation were scheduled for immediate remedial action under the draft feasibility study. A final feasibility study was scheduled for release in the Spring of 1989. A Consent Decree and other agreements were completed in Fall 1991, but the site was still contaminated in March 1993.

USEPA estimated that the cleanup requirements in SARA would drive the cost of a typical Superfund cleanup from an average of $8 million to $9 million per site[3] to between $25 million and $30 million per site. States are responsible for paying 10 percent of the cleanup costs at fund-financed sites (Hellman and Hawkins, 1988, p. 100). The 1988 OTA case study of Superfund cleanups found that "total clean costs can reach $500,000 to $1 million per acre" (OTA, 1988, p. 2).

ILLINOIS

In Illinois, there were 1173, 1304 and 1382 CERCLIS sites in 1987, 1989 and 1991, respectively (NGA, 1992). In these years, 27, 38[4] and 37 of these were NPL sites (as of July 1991), and 33, 50 and 45 were on the National Governors' Association list (NGA, 1992, Appendix C). In December 1992, there were 40 NPL sites, 1 site was proposed for the NPL, and 277 sites were under various stages of investigation. The number of sites, type of chemical contaminant, and affected medium are given in Tables 19.4 and 19.5.

The public water supply wells in Rockford are an example of how the information in Tables 19.4 and 19.5 was developed. "Contamination of groundwater in southeast Rockford is considered a particularly acute threat to human health and the environment due to the significant number of private and municipal drinking water wells located in and near the contaminated area" (IEPA, 1989, p. 28). Contaminants found in wells included chloroform, Aroclor 1221 (a PCB mixture), 1,1-dichloroethane,

Table 19.4. Number of Illinois Sites in 1991: Type of Chemical Contaminant and Affected Medium

		Type of Contaminant[3]			
Medium	Number (%) of Sites[1]	Organic Chemical	Inorganic Chemical	Radionuclide	Petroleum[2]
Land Area	45 (56)[4]	40[5]	15	4	0
Surface Water	21 (26)	17	12	4	0
Groundwater	14 (18)	13	2	1	0
Waste Pond/Lagoon	0 (0)	0	0	0	0
Building	0 (0)	0	0	0	0

[1]Some sites involve more than one environmental medium and type of chemical contaminants, so the sum of the sites is greater than the total number of sites reported in Illinois.
[2]Gasoline and fuel oil.
[3]For perspective, the most frequently found contaminants at all sites in EPA region V in 1989 were: PCB (65), trichloroethylene (55), benzene (25), lead (24), and perchloroethylene (23). In 1991, they were mercury (200), PCB (136), trichloroethylene (92), volatile organic compounds (VOC; 84), and lead (74).
[4]Nationally in 1991, 40 percent, 24 percent, 57 percent, 6 percent and 3 percent of 2,302 sites were restricted due to land area, surface water, groundwater, waste pond/lagoon, and building. The number of listed sites increased 35 percent from 1,705 sites listed in 1989.
[5]Nationally in 1991, 73 percent of the sites were restricted due to contaminants classified as "organic chemicals", 44 percent as "inorganic chemicals", 11 percent as "gasoline and fuel oil" (petroleum), 3 percent as "radionuclides."

Source: NGA, 1992, Table D-2.

1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethene, trans 1,2-dichloroethene, tetrachloroethene, chromium, and lead. As of January 1986, the area of contaminated groundwater encompassed at least two square miles.

It was obvious from the beginning that funding was the essential key to how many, and how fast sites could be cleaned up. Consequently, the Illinois General Assembly took the initiative and created a State-funded hazardous waste program. The history of the State's effort was summarized by IEPA (1988, p. 15) as follows:

While Congressmen in Washington were still struggling with pre-CERCLA hazardous waste bills, Illinois legislators were amending the state's Environmental Protection Act to create a Hazardous Waste Fund (HWF) to provide funding for hazardous waste cleanups in the state.

In 1981, by legislative action, landfilling of any hazardous wastes was banned in the state after January 1987. As the list of identified potentially hazardous sites in Illinois grew, it rapidly became obvious that the HWF alone would not be adequate to fund all responses. Many of the sites did not score high enough to be placed on the federal NPL and would require state-financed cleanups. It could be safely assumed that emergency cleanups would also continue to occur, requiring immediate response funding. Even in cases which qualified for federal assistance, the state's 10 percent matching fee requirement remained. In 1983, the Illinois General Assembly created a framework for a state program fashioned after CERCLA. The Illinois plan called for the Illinois Pollution Control Board to adopt a contingency plan similar to the NCP to guide state cleanups, with the IEPA authorized to implement and oversee the remedies and pursue the potentially responsible parties.

In June 1984, then Governor James R. Thompson and legislative leaders launched a $20 million state-funded attack on abandoned hazardous wastes sites in the State. The program, nicknamed "Clean Illinois," was funded[5] to aggressively deal with dozens of landfills and industrial sites which were polluting or threatened to pollute the environment (IEPA 1988). The program is managed by the Illinois Environmental Protection Agency (IEPA). However, other state agencies also respond to hazardous waste issues.

The Illinois Department of Public Health (IDPH) administers the Illinois Health and Hazardous Substance Registry Act, and provided coordination

Table 19.5. Number of Closed or Restricted Groundwater Wells in Illinois Contaminated by Most Commonly Found Contaminants

Chemical Contaminant	Number of Closed Sites	Chemical Contaminant	Number of Closed Sites
Alachlor	0	Freon	0
Aldicarb	0	Gasoline	0
Arsenic	119	Heavy Metals	135[1]
Barium	0	Lead	215
Base Neutrals	0	Mercury	0
Benzene	2	Methylene Chloride	5
Beryllium	0	Nickel	8
Bromacil	0	Nitrates	0
Cadmium	8	PAHs	0
Carbon Tetrachloride	0	PCBs	131[1]
Chlorinated Hydrocarbons	119	Perchloroethylene	200[1,2]
Chloroform	208[2]	Pesticides	121[1]
Chromium	213[2]	Phenols	8
Cyclonite	0	Phthalates	5
DDT	0	Toulene	10
1,1-Dichloroethane	208	1,1,1-Trichloroethane	205
1,2-Dichlorothylene	200	Trichloroethylene	216[1,2]
Ethylene Dibromide	0	Vinyl Chloride	11
Explosives	0	VOCs	224
Fertilizers	0	Xylene	18
Total Number of Wells Affected		364	

[1,2]Most frequently found contaminants in closed or restricted groundwater wells in Region V in 1989[1] and 1991[2].

Source: NGA 1992, Table D-3.

Table 19.6. Total Number of Illinois Cleanup Projects, Cleanup Expenditures and Cleanups Completed in Fiscal Years 1985-1990

	Fiscal Year					
	1985	**1986**	**1987**	**1988**	**1989**	**1990**
No. of Projects[1]	51	97	142	181	245	--
Cleanup Expenditures[2]	1.53	4.48	13.86	15.43	9.75	15.0
Cleanups Completed	5	7	9	8	12	

[1]Cumulative total
[2]Millions of dollars

Source: IEPA, 1989.

with IEPA and the Centers for Disease Control (CDC) in Atlanta regarding cleanup levels. The Department of Energy and Natural Resources provides research and publications on related hazardous waste concerns (IEPA 1988, p. 16). When it began, 13 sites were named to the State Remedial Action Priorities List (SRAPL). In 1988, the SRAPL was expanded to include 29 locations for priority cleanup using State funds. By mid-1989, 4 NPL and 37 other sites had been cleaned up. Completed projects included three SRAPL sites and 12 immediate removal projects. The responsible parties paid the cleanup costs at 26 of these sites (IEPA 1989). By December 1992, there were 35 SRAPL sites, 8 deferred SRAPL sites, 4 remediated SRAPL sites, and 70 sites were slated for immediate removal. Cleanups had been started or completed at 110 sites. For fiscal years 1985 to 1989, the numbers of cleanup projects, cleanup expenditures, and cleanups completed reported by the IEPA (1989) are given in Table 19.6. A 1992 appellate court decision invalidated the IEPA rule upon which the SRAPL list was based. Legislative or regulatory action to address this situation is expected.

For the past three years there has not been adequate money in Illinois clean-up fund. The IEPA reports a current backlog of 146 sites as of August 1993 needing remediation. For the past four years proposed legislation to increase the hazardous waste disposal fee to raise the needed funding has failed to pass. EPA estimates that at least 900 sites will require some type of cleanup.

INNOVATIVE CLEANUP TECHNOLOGY

As described in its 1988 "Cleaning Illinois" report, IEPA began to recognize during the first year of the "Clean Illinois" program that a tremendous amount of hazardous waste would have to be landfilled as a result of state-funded cleanups.

Potential problems with environmental liability, state and federal landfill disposal restrictions and transportation and disposal costs caused the Agency to revise its hazardous and toxic waste clean up policy. The Agency now requests the use of alternative treatment technologies such as incineration, and is less dependent on landfill disposal of hazardous wastes generated from cleanup operations...[T]he high cost of transporting and managing large volumes of contaminated sludges and debris [to commercial stationary incinerators] caused the IEPA to utilize mobile incineration systems. The IEPA believes there are several good reasons for using mobile incineration as an alternative to landfill disposal:

1) because it is totally transportable, the incinerator rather than the hazardous waste is removed. The incinerator is assembled on site, the wastes are burned, then the unit can be disassembled and hauled to the next site where it is needed;

2) unlike landfill disposal where hazardous and toxic wastes remain in the environment, incineration is a permanent solution which destroys the hazardous components of the waste;

3) the system provides nearly complete combustion of all organic contaminants fed into the system, including persistent non-biodegradable compounds as well as debris sludges and soils from cleanup operations;

4) the process has a proven track record. The same type of technology is used at several commercial treatment facilities;

5) by destroying hazardous substances where they are found, the state can limit its environmental liability associated with landfill disposal of cleanup residues and eliminate their transportation on state highways.

In 1987, the IEPA approved permits for the first two large scale, sponsored incineration projects in the United States. One was located near Beardstown, where a modular incineration system burned soils and debris contaminated with PCBs. The second operated near Lemont, to destroy hazardous liquids, sludges and soils. IEPA incinerated large amounts of soil and debris at LaSalle Electrical Utilities Superfund site (IEPA, 1989). IEPA was considering using incineration at the Savanna Army Depot in Jo Daviess county (IEPA, 1988), but was still negotiating the cleanup program a year later (IEPA, 1989). The Interagency Agreement with the Department of Defense became effective in January, 1990. The trial burn plan was submitted in August 1992 and a trial burn during October showed that the incinerator was meeting all emission requirements.

In 1984 the Hazardous Waste Research and Information Center (HWRIC) was establish within the Department of Energy and Natural Resources (DENR) with the mission of helping to find solutions to the state's hazardous waste problems. One component of that mission has been to develop and evaluate remediation technologies. To date several new, effective technologies have been developed and, in some cases, field tested. These new technologies could save the State and industry money and time in cleaning contaminated sites. With the reductions in funding over the past three years, HWRIC's ability to develop these technologies and demonstrate their effectiveness has been severely hindered.

HOW CLEAN IS CLEAN?

The answer to the question "How clean is clean?" is more like a philosophy in that the answer depends, in part, on an individual's belief system. Various responders define "clean" as when:

1) the composition of the polluted medium is restored to the original background;

2) the cost of cleanup exceeds the benefits;

3) the medium can maintain an ecosystem similar to that which existed before the contamination;

4) the medium can maintain an ecosystem appropriate to the nature of the medium following restoration.

The first statement, when conditioned by the second, represents the philosophical basis of RCRA, CERCLA, and most state programs. However, environmental standards currently exist for only a small fraction of cleanup situations, especially for safe limits of contaminants in soils[7,8]. Consequently, EPA establishes cleanup levels using risk assessment with a broad range of acceptable risks, from 1 in 10,000 to 1 in 10 million[9]. Risks considered include the hazard potential of substances present at the site and potential for contaminating drinking water.

"[This] approach results in the establishment of different acceptable levels of contamination in the ground water, surface water, and air from site to site across the country after a cleanup....The major objection that environmental and community groups have about the current USEPA approach is that it does not guarantee a minimum level of protection to citizens across the country; rather, a number of factors, many of which are never quantified or explicitly discussed, appear to determine the amount of contamination that will remain at the site after cleanup" (Greer, 1988, p. 111).

Killian (1989) has noted that "...if the allowable level of risk is not held constant, 'How Clean is Clean?' levels become 'moving targets' and the probability that they will be applied inconsistently increases significantly." State officials have concluded, "The lack of development of cleanup standards or goals has been a major impediment in achieving a more rapid remediation of hazardous waste sites throughout the country...The overall goal of developing cleanup standards, models, and criteria should be to assure a consistent approach to the cleanup of hazardous waste sites" (ASTSWMO, 1989).

Some environmental groups believe this statement to be the correct test of "clean," even if costs outweigh benefits or it is technically infeasible to restore the original ecosystem. Other environmentalists accept the last statement (possibly conditioned on the second) as the test of "clean." As explained by Greer (1988, p. 110), after lobbying the issue of cleanup levels for hazardous waste dump sites during the 1980 debate over the Superfund bill, the Environmental Defense Fund (EDF) oversaw the implementation of the statutory language and participated in the rule making that generated the National Contingency Plan (NCP), the set of regulations governing cleanups nationwide. EDF subsequently filed suit against EPA in 1982 over the agency's failure to resolve the cleanup issue in the NCP.

Since 1982, the "How Clean is Clean?" question has expanded to include not only the question of the level of cleanup appropriate at dump sites but also the technology to be selected in undertaking a cleanup and the point of compliance at which the cleanup goals will be attained. These issues have been addressed by environmental and citizens groups at particular sites as well as in lobbying efforts on the 1986 reauthorized Superfund bill [SARA].

Hellman and Hawkins (NRC, 1988) provide an interesting case study which focuses on some of the issues associated with defining "clean." Cleanup of a particular groundwater contaminated with trichloroethylene (TCE) at 20 ppm was initiated by air stripping at a rate of 85 ppm. After 2.5 years of continuous pumping the TCE concentration in the aquifer had dropped to 1.3 ppm (93.5% reduction), and an additional 2 years of pumping reduced the concentration to 1.0 ppm (95% reduction). The total costs at the end of each period were $222,000 and $312,000. Further pumping to drop the concentration to 0.1 ppm (99.5% reduction) would require an additional 16.5 years and would raise the cost to $1.1 million, while reduction to 0.01 ppm (99.95% reduction) would require 95 years more and would cost over $10 million. "It raises the practical question of who will be responsible for these kinds of abatement systems 20 to 50 years from now when the companies deemed responsible may no longer exist" (NRC, 1986,p. 103). This example illustrates the maxim that the first 90% of the reduction requires 10% of the cost while the last 10% of the reduction accounts for 90% of the cost.

This raises the important practical question: "Is society better served by cleaning relatively few sites extensively or more sites to less restrictive levels?" In a review of Superfund, the Office of Technology Assessment (OTA 1989, p. 26) concluded:

> "The unsuccessful attempt to balance Superfund's environmental goals against technical and economic resources has revealed the lack of a well-crafted long-term strategy in statute or implementation...The question, therefore arises: what is the most efficient means of allocating Superfund's limited resources to achieve maximum protection of the public and environment? The answer to this question lies in how the spending is to be distributed with respect to sites and time....[S]trategy, not just spending, has to be considered."

The same criticisms that have been leveled at Superfund, CERCLIS and the NPL are appropriate to other federal programs, and to state funded programs, which operate in the Superfund framework. However, the failure of Congress and EPA to provide criteria to determine "How Clean is Clean?" is an opportunity for the "Clean Illinois" program to answer the question and pioneer the methodologies to ensure that a clean Illinois is achieved to maximum extent possible. A successful methodology should achieve a reduction in adverse health risks and increase the health protection (not necessarily complete cleanup) for the greatest number of people possible.

A successful methodology should also achieve a reduction in adverse health risks and increase the health of exposed ecosystems. These environmental goals were articulated by Congress twenty years ago in the "fishable and swimmable" goal of the Clean Water Act (1972). Title III of the 1990 Clean Air Act Amendments of 1990 requires the Administrator of EPA to regulate substances that defined by Congress:

> "...are known to cause or may reasonably be anticipated cause adverse effects to human health or *adverse environmental effects*. [T]he term "adverse environmental effects" means any threat of significant adverse effects, which may reasonably be anticipated, to wildlife, aquatic life, or other natural resources including disruption of

local ecosystems, impacts on populations of endangered or threatened or species, significant degradation of environmental quality over broad areas, or other comparable effects."

Furthermore, SB442 enacted by the State General Assembly (1 January 1988) amended Section 9.5 of the State's "Environmental Protection Act" (approved June 29, 1970) as follows (emphasis added):

1) The public health and welfare may be endangered by the release of *toxic contaminants* into the air which are carcinogenic, teratogenic, mutagenic or otherwise *injurious* to humans or *the environment.*

2) Existing federal programs may not be adequate to *protect* the public and *the environment from low-level, chronic exposure to toxic air contaminants.*

   c. The [Pollution Control] Board...shall promulgate a list of toxic air contaminants. The list published under this subsection shall include any air contaminant which may...pose a significant threat to human health *or the environment.*

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Endnotes:

[1]On March 19, 1993, Illinois Power (IP) and Waste Recovery, Inc., of Dallas announced that they "plan to *recycle* more than half the 12 million tires discarded in Illinois each year while creating as many as 70 new jobs in southeastern Illinois and the Ottawa area...Waste Recovery intends to build plants in two locations to convert used tires into power plant fuel. IP expects to *burn* 7.5 million reprocessed tires annually, equal to about 60 percent of tires discarded statewide each year" (The Champaign-Urbana News-Gazette, p.2, italics added).

[2]Based on these error rates, approximately 20-25 Illinois sites on the NPL should not be there and approximately 100 Illinois sites on CERCLIS need to be added to the NPL.

[3]EPA provided an average cost estimate of $8.84 million (1986 dollars) in a Superfund Section 301(a)(1)(c) study of future funding needs.

[4]According to "Cleaning Illinois" (1989, p. 3): "In 1984, 11 sites appeared on the National Priority List (NPL) of Superfund. Today [1989], 23 Illinois facilities are named on the NPL." Since the NGA numbers quoted here were obtained from IEPA, the reasons for the discrepancy possibly reflect an unspecified distinction between "site" and "facility."

[5]"Clean Illinois" is funded by the "Build Illinois" bond program and the State's Hazardous Waste Fund. The fund generates about $2.5 million annually from a fee on treatment and disposal of hazardous waste in Illinois. The State also receives any cleanup settlement revenues recovered on specific site agreements. However, in the first four years (1985-1989) of "Clean Illinois," the legislature appropriated less than half of the $90 million originally earmarked for cleanup work under the "Build Illinois" bond program (IEPA 1989, p. 5).

[6]For example, as discussed elsewhere in the CTAP report, dewatering of sewage sludge is carried out in order to reduce the volume of sludge which must be transported.

[7]Sims et al. (1988) present information and mathematical models for the quantitative evaluation of the treatment potential in soil for 56 hazardous chemicals. The chemicals were organized into four categories of substances: 1) polynuclear aromatic hydrocarbons (PAH); 2) pesticides; 3) chlorinated hydrocarbons; and 4) miscellaneous chemicals. Treatability screening studies were conduced to determine: 1) degradation rates; 2) partition coefficients among air, water, soil, and oil phases; and 3) transformation characteristics.

[8]The Dutch Ministry of Housing, Physical Planning and Environment developed a list of soil quality reference values to implement the country's Soil Protection Act of 1986. See van Straalen and Denneman (1989).

[9]Many people live within 4 miles of several waste sites, as shown by 1990 Donnelly estimates: 1 site, 28,386,886 people; 2 sites, 7,485,909 people; 3 sites, 2,966,698 people; 4-10 sites, 2,069,228 people; and >10 sites, 186,416 people (NRC 1991, p. 114). However, EPA establishes cleanup requirements separately for each site. Because sites enter the various stages of the process at different times, some individuals could be exposed for decades.

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Identifying contaminants that may be impacting our natural resources is an important step toward environmental protection. This volume of The Changing Illinois Environment: Critical Trends, Waste Generation and Management, pulls together information about the kinds of wastes produced in Illinois and how they are treated, disposed, or recycled. The volume focuses primarily on solid waste issues and land-based management methods but also examines the emerging multimedia (air, land, and water) approach to environmental regulation. A discussion of efforts to clean up hazardous waste sites in the state is included as well a chapter about Illinois industry's success with pollution prevention as a means to comply with environmental regulation and improve efficiency. Volume includes numerous tables, figures and maps as well as an extensive bibliography of literature cited and reviewed.

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