APPENDIX E

BACKGROUND DATA:
CLASS I AND CLASS III ISSUES

TABLE OF CONTENTS

E.1 Requirements and Sources of Water-Use Data

The first step in determining whether a substantial population is affected is to identify ground waters in the Classification Review Area (CRA) serving as drinking water sources. It will be necessary to determine whether these are the sources of local town or city drinking water, and to distinguish between centralized public water systems and decentralized private wells.

If the ground water feeds public supplies, the following determinations should be made:

- Locations of wells for public water supply;
- Well depths and pumping rates, if available;
- Areas serviced by public water mains from the source being classified;
- Whether the ground water is the only source for the population it supplies;
- Percentage of water originating in the Classification Review Area used for household purposes (factoring out industrial and irrigation uses);
- Number of households supplied by public system (data are likely to be reported in this form); and
- Number of persons per household for the area, as reported by the Census Bureau, to determine the population supplied by the public system.

The first step in obtaining this information is to contact local and state organizations with responsibility for maintaining records of drinking water supplies and usage for the area. These agencies include:

- Federal/state/local geological surveys;
- State/local health departments;
- State/local water departments;
- Local water treatment facility;
- Local water utility;
- State department of natural resources; and
- State department of energy.

One or more of these organizations should maintain accurate records of public water usage, most likely in terms of the number of households or hookups supplied by the public system. This number may be translated into an estimate of the population served by using the number of persons per household reported by county in 1980 Census of Population state summaries (see detailed references). Water used for industry or irrigation need to be disaggregated so that only drinking water usage is included.

Where public water sources do not supply the residents within the affected area, detailed information on private wells will be needed. The same agencies mentioned above may also have information on private wells. Private sector organizations that may have useful information include water companies and well-drilling firms.

E.2 Use of GEMS System for Estimating Well Density

One means of estimating private well usage in areas where no local information on private wells is available, is to use population data for the area of interest available through the Graphical Exposure Modeling System (GEMS) maintained by EPA's Office of Toxic Substances, or a private census data service (see list of organizations registered with the National Clearinghouse for Census Data Services in Appendix E).

Information on the GEMS system is available from EPA's OTS modeling team. Using the GEMS Census Data (CD) procedure, it is possible to retrieve population and housing count data from the 1980 Census for circular areas around a point, which can be designated using latitude and longitude coordinates or the ZIP code of the location. The system provides information within defined concentric rings ranging from 0.1 to 10,000km in radii. It is necessary to supply the number of sectors into which the rings are divided; the procedure allows from 1 to 16. Sectors are numbered clockwise with the first sector centered at zero degrees (the north compass point direction). The program tabulates total population and housing counts by ring distance and sector. A simple mathematic conversion can be used to transform the population counts into density.

The manner in which population data are recorded by the Bureau of the Census and reported by GEMS can result in reports of no population for some areas where people are living. This information can be verified or corrected by consulting local officials. It is unlikely that such areas would satisfy the densely settled test, however.

E.3 Densely Settled Criterion

If private wells in the CRA are found to serve at least 2,500 people, the densely settled criterion will be met if the CRA is part of a census-designated densely settled area. If it is contained in an Urbanized Area as described by the Census Bureau, the population is by definition densely settled unless it can be shown to meet any of the exceptions described under the definition of a densely settled area. Census Designated Places (CDP's) also by definition are densely settled. These are unincorporated places with a population density of at least 1,000 persons per square mile. They are outlined on Census tract maps for metropolitan areas, on block numbering area maps in nonmetropolitan areas of less than 10,000 people (see Appendix F).

Key terms used by the Census Bureau as follows:

- Metropolitan statistical area (MSA): (a) a city of at least 50,000 population, or (b) a Census Bureau-defined urbanized area of at least 50,000 with a total metropolitan population of at least 100,000 (75,000 in New England). There are 277 MSAs (as of June 30, 1984). Every state has at least one MSA.

- Urbanized area (UA): a population concentration of 50,000 or more, generally consisting of a central city together with its surrounding densely settled contiguous territory or "suburbs" (the urban fringe). There are about 420 UA's.

- Urban place: any population living within urbanized areas; or places of 2,500 or more people outside urbanized areas.

- Densely settled area: not an official statistical division, but used by the Census Bureau to indicate an area with a population density of at least 1,000 persons per square mile within an urbanized area or Census Designated Place (CDP).

Urbanized Areas may include areas which do not qualify as densely settled, (e.g., less than 1,000 persons per square mile) but are included within such geographic boundaries because they either:

- Eliminate enclaves of less than five square miles which are surrounded by built-up areas.

- Close indentations in the boundaries of densely settled areas that are no more than one mile across the open end and encompasses no more than five square miles.

- Link outlying areas of qualifying density, provided that the outlying areas are:

  (a) Connected by road to, and are not more than 1-1/2 miles from, the main body of the urbanized area.

  (b) Separated from the main body of the urbanized area by water or other undevelopable area, are connected by road to the main body of the urbanized area, and are not more than five miles from the main body of the urbanized area.

- Are nonresidential urban areas (e.g., industrial parks, office areas, or major airports), which have at least one-quarter of their boundaries contiguous to an urbanized area.

MSA's and their components are listed in the <u>1980 Census of Population - Supplementary Report: Metropolitan Statistical Areas</u> and are mapped on State MSA outline maps. Urbanized area (UA) outline maps are generally contained within MSA publications.

E.4 General Background Information on Institutional Constraints

Institutional constraints on the availability of water can arise from at least six general sources. Each of these is discussed below.

E.4.1 State Law

State law creates basic rights to the withdrawal and use of surface and ground water. For example, state law may regulate the rights to or ownership of water, the withdrawal, uses and allocation of water, conjunctive use of surface and ground water, protection of instream users, and measures required to protect ground water. The law in most states, however, does not create a right to unlimited amounts of water, and may restrict where the water may be used (U.S. EPA, 1985; Council of State Governments, 1983). The states have created different methods for establishing rights to water and resolving conflicts over rights to withdraw and use water. There are three major systems of regulation of water withdrawal and use:

- The Eastern (common law) doctrine, used in about 37 states, provides that ownership of land carries with it a right to water in adjacent lakes or watercourses (a riparian right) and to water beneath the land. The use of the water, however, may be restricted. Under the absolute use doctrine it is possible for a landowner to withdraw unlimited amounts of water, without liability for damage to other landowners, and to transport the water off the land. Under the reasonable use doctrine it is possible to withdraw an amount of water necessary for the use or enjoyment of the overlying land, but the water may not be transported away from that land. Under the correlative rights doctrine, the right to withdraw ground water is based on the relationship between the size of the aquifer and the area of the overlying land.

- The Western (appropriation) doctrine, used in about 13 states, provides that water is a public resource, and rights to water may be acquired by actual use. Conflicts in priority of use are ordinarily settled by the principle of "first in time, first in right." Hierarchies of use, however, may also be established.

- Permit systems, used in about 31 states, may be used in conjunction with the common law or appropriation doctrines, and may be applied to surface and/or to ground water. Rights to water under a permit system are acquired by application to a regulatory authority. If the authority determines that no superior claim exists to the water, it records the claim, issues a permit for use, and polices the actual use. Permit systems may co-exist with other forms of water regulation, such as designated ground-water protection zones or management areas. Many permit systems specify priorities for different types of uses of water (beneficial uses), generally making domestic use, such as drinking water, the highest beneficial use and making other uses, such as commercial or industrial use and irrigation, lower beneficial uses.

Conflicts among users, or prospective users, of water are resolved by most states in three ways: the conflict may be decided by the administrative organization that administers the water rights system in the state, particularly if water use permits are required; special organizations may be created to resolve water disputes; and the state or local courts may resolve disputes. State law in certain circumstances may allow the use of eminent domain powers to shift water from one use to another, or to allow physical access to water, and state law may grant the use of eminent domain to the Federal government for certain purposes. Frequently, when insufficient water exists for all claimed uses, lower beneficial uses may give way to higher beneficial uses.

Some states have attempted by law to restrict or preclude the export of water to users in other states, either by requiring legislative approval of water exports, by requiring reciprocity agreements with the states receiving the water, or by absolute prohibitions. All of these forms of restriction have recently been subject to legal challenge.

A number of states, particularly in the West, designate ground-water protection zones or management areas, and seek to coordinate surface and ground-water use (conjunctive management). Measures of conjunctive management may include restrictions on pumping ground water, requirements for aquifer recharge, and well spacing requirements. Some states (e.g., Texas, Nebraska) delegate aquifer protection authority to local administrative bodies.

E.4.2 Federal Law

As a user of water, the Federal government generally defers to state regulation of water. Federal laws often pertain to Federal and Indian reserved rights to water and Federal activities affecting water. In common law States, Federal rights to water are linked to ownership or control of land. In prior appropriation and permit States, Federal agencies (e.g., the Bureau of Reclamation) register claims to water. The Federal government may, however, have special access to water in certain circumstances. Statutes (e.g., the Oil and Gas Well Conversion Act) or executive orders (e.g., the Executive Order of April 17, 1926) may reserve water rights on Federal public lands for particular purposes.

For certain categories of Federal lands withdrawn from the public domain and reserved for such uses as national forests, wildlife refuges, and parks, Federal reserved rights doctrine can provide access to water irrespective of State law. The courts have created this doctrine, which holds generally that reservation of public domain lands for a particular purpose carries with it an implied reservation of sufficient water to satisfy the purposes for which the land was reserved. The right is not created by use or lost through non-use. Therefore, in certain circumstances, even if the water is being used by another person, the Federal government can obtain water for its own use. The purpose of the water is determined as of the time the land reservation was created, and the reserved right is limited to that purpose. (For example, if the reservation was created to provide agricultural land, reserved rights to irrigation water may exist, but there are no reserved rights to water for industrial purposes.)

An Indian reserved right, similar to the Federal reserved right, has also been created by the courts. This doctrine is apparently based on the presumption that in creating an Indian reservation the President and/or Congress intended to reserve sufficient water for the use of the land. Indians may hold superior rights to water connected with reservation lands. Apparently, such rights may be sold, although it is unclear whether only the amount of water actually being used or the entire potential right may be transferred. In addition to reserved rights, in a few instances Indians also hold special water rights based on treaties (e.g., Treaty of Guadalupe Hidalgo).

Federal water resource agencies, such as the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service, as well as such Federally-chartered agencies as the Tennessee Valley Authority and the Bonneville Power Authority, can affect water availability, either through the water rights that they hold or through their decisions concerning water management (Congressional Budget Office, 1983). Numerous other Federal agencies and laws can affect water resource decisions indirectly. Examples of such agencies or laws include the Forest Service and Bureau of Land Management (right-of-way decisions), the Fish and Wildlife Service (requirements under the Fish and Wildlife Coordination Act), the National Environmental Policy Act (Environmental Impact Assessment requirements), Clean Water Act (dredge and fill permit requirements) and the Wild and Scenic Rivers Act and National Wilderness Preservation requirements.

E.4.3 Interstate Compacts

Conflicts among two or more states or the Federal government concerning rights to water in streams generally are resolved either through interstate compacts or through litigation (Clyde, 1982, 1984; Schwartz, 1985; Sporhase vs. Nebraska, 1984). The result in either case is usually a decision allocating the in-stream flow among the states claiming the water. In a few cases, ground water has also been allocated among states by interstate compact or court decision.

E.4.5 Treaties and International Laws

Treaties between the United States and its neighbors, Mexico and Canada, allocate the waters of rivers flowing between the countries. The 1944 Treaty of Utilization of the Waters of the Colorado and Tijuana Rivers and the Rio Grande, for example, apportions the waters of those rivers between the two countries and creates an International Boundary and Water Commission (IBWC) to apply the treaty and settle disputes. Although ground water use is not fully covered by the treaty, the IBWC has attempted to address the management of international ground-water resources.

In addition to treaties signed by the United States, certain international law proposals being developed by the United Nations and the International Law Association may sometime in the future establish general principles for the allocation of ground and surface waters between two countries.

E.4.6 Property Law

State law governs the ownership and use of land. In particular, "property law" affects physical access to water supplies through restrictions on rights of way and easements, or defining powers of eminent domain. State and lcoal law generally regulates land use and access to land by persons who are not landowners. Access to water, including the location of pipes, storage, pumping, treatment, and other facilities can be delayed or restricted by the property rights of persons whose land must be crossed or used for such facilities. Special procedures, such as easements, eminent domain, and condemnation may be required to obtain necessary rights-of-way. Special procedures vary from state to state.

E.5 Irreplaceability: The Annualization Factor

An annualization factor may be used in comparing economic feasibility in the irreplaceability test. The annualization factor (AF), also known as a real capital carrying charge, is given by:

$$AF = \frac{r}{1-1/(1+r)^n}$$

where r = real interest rate
n = life expectancy of capital equipment

The annualization factor is derived to obtain equal annual payments of capital costs in constant dollars (i.e., adjusted for inflation). This annualization factor is equivalent to the formula used to obtain a total of n equal annual payment for a fixed mortgage in real dollars, where r is the real interest rate for the mortgage.

The choice of real interest rates depends on the costs of available financing for water supply alternatives. The U.S. Office of Management and Budget (OMB) recommends that a ten percent (10%) real interest rate be used to discount capital costs in the analysis of regulatory options. Therefore, an interest rate of ten percent can be used to derive annualization factors. Alternatively, real interest rates on tax exempt bonds used to fund water projects can be used in the analysis.

Municipalities and local governments can rely on tax-exempt bonds to finance their water supply projects. According to Standard & Poor's, the average nominal interest rate on tax exempt bonds was 9.0% in May 1985. The yield on individual bonds would depend on the bond rating. Real interest rates on tax-exempt bonds can be derived from nominal rates (i) by the following formula:

$$r = 1 - \frac{1 + i}{1 + e}$$

where: r = real interest rate
i = nominal interest rate
e = expected rate of inflation

Assuming an expected rate of inflation of 4 percent

$$r = \frac{1+.0908}{1+.04} - 1$$

$$= 1.049 - 1$$
$$= .049 \approx .05 \text{ or 5 percent}$$

Annualization factors are calculated here for both 5 and 10 percent real interest rates.

Dereivation of the annualization factor (AF) is affected by the expected life of the capital equipment (n). The appropriate life-expectancy value to be used depends upon many factors, including the type and complexity of equipment and annual operating and maintenance schedules. Typically, a value of 30 years is a reasonable life expectancy for a water treatment plant involving conventional techniques such as sand filtration, flocculation and precipitation, and chlorination. Other, simpler systems may remain operational for longer periods and certain components (such as valves, montioring equipment, or motors) may not last 30 years. Capital costs can be annualized by three single steps:

(1) Estimte capital costs
(2) Estimate annualization factor
(3) Multiply capital costs time annualization factor to obtain annualized costs.

Table E-1 provides three annualization factors that incorporate alternative assumptions for life expectancy of the capital equipment, assuming a real interest rate of five and ten percent, respectively. The values from the table above can be used directly to annualize capital costs. After capital costs are annualized, they should be added to annual O&M costs to obtain the total annual costs.

The procedure for annualizing capital costs can best be illustrated by a numerical example:

Assume Capital Costs	= $1,200,000
Real interest rate	= 10% or .10
Life expectancy of capital equipment	= 30 years

Then

$$AF = \frac{r}{1-1/(1+r)n}$$

$$= \frac{.10}{1-1/(1+.1)^30} = \frac{.10}{1-1/17.449}$$

$$= \frac{.10}{.943} = .106$$

Annaulized Capital Costs = Capital Costs x AF
= $1,200,000 x .106
= $127,200

E.6 Water Costs vs. Water Rates

Ground-water classification for Class I - Irreplaceable would normally require an assessment of the economic costs of an alternative water supply under both the qualitative and quantitative approaches for judging irreplaceability. The discussion in this section indicates that rates changed by a water supply utility may not reflect economic costs for various reasons. This implies that when the feasibility determination is not clear-cut and when sufficiently detailed

TABLE E-1
ANNUALIZATION FACTORS

n (Life Expectancy of Capital Equipment)	AF (Annualization Factor)	
	r = .10	r = .05
15	.131	.096
30	.106	.065
40	.102	.058

cost accounts are available from the utility, these should be used in preference to the rate schedules to estimate costs.

The economic cost of the water supply may differ from the charges made to the community by the utility for a number of reasons. The utility may not set rates on the basis of economic costs of supply, or the utility may not face the true economic costs. Rates and fees may be set with reference to the <u>average</u> costs of the utility, whereas the economic costs of additional water supply capacity are the <u>marginal</u> (or incremental) costs of this capacity. Secondly, the utility may charge different rates to different types of users in such a way that one type of user (e.g., industrial users) implicitly subsides other types of users (e.g., households). The concepts are illustrated in examples below.

Consider a hypothetical system that serves 10,000 households. It has annual O&M costs of $500,000 and annualized capital expenses of $500,000 (including an allowance for an acceptable return on capital). Therefore the total annyal expenses of the system are $1,000,000. The utility charges all households served by the system the same flat rate of $100 per annum to recover costs and capital charges of $1,000,000. Suppose that the system is expanded to serve 100 additional users; O&M costs increase to $60,000, capital charges increase to $600,000. The one time costs of connecting the new users of $100,000 are recovered immediately by charging each additional user a connection fee of $100. The utility re-computes rates of 11,000 users based on total costs and capital charges of $1,2000,000, and so charges each user $109.09 ($1,200,000 divided by 11,000). The charges to the new users are the total connection fee of $100,000 plus $109,000 annually (1,000 multiplied by $109.09) for a total of $119,090. However the true costs to the system of the additional users is $109,000 connection costs plus $200,000 annually ($1,309,000 minus $1,000,000) for a total of $309,000. Therefore the rates and fee charged tot he new users understate the true economic costs. The converse is also possible; marginal costs may be lower than average costs so the charges to new users may exceed the true economic costs.

Consider a system serving 10 industrial users and 1000 households. Total system costs are $1,000,000 per annum. The system supplies supplies 200,000,000 gallons annually. Each household uses an average of 100,000 gallons per annum and each industrial user takes 1,000,000 gallons per annum. The utility charges industrial users of 0.75 cents per gallon, raising annual revenue of $75,000, and charges households a flat rateof $25 per annum, raising a further

$25,000. Total revenues are $100,000 which covers the cost of the system. Household users are charged an average of 0.25 cents per gallon, and so are implicitly subsized by industrial users. Economic costs of the system are 0.50 cents per gallon, which exceeds the implicit per-gallon charge to household, and is less than the per-gallon charge to industrial users.

A further general reason that utility rates may not reflect economic costs is that the utility does not face the full economic costs of the system. This can arise if the utility's capital expenditure is subsidized by grants and loans from State or Federal agencies, or by preferential tax treatment. This introduces a further potential source of difference between rates and economic costs.

In cases where cost accounts are not available, the financial accounts of the utility should provide some information that may be used to adjust rate schedules to more closely reflect economic oosts. For example, capital grants for construction received by the utility from state and Federal funds will be shown on the balance sheet. This can be compared with total plant costs (the book value of these fixed assets) to find the proportion of capital costs borne by the utility. Suppose 50 percent of the capital costs are paid for by grants and 50 percent by the utility. Annualized capital expenses are 60 percent of total operating expenses. In this case, the utility is effectively subsidized for 30 percent of total operating expenses. In this case, the utility is effectively subsized for 30 percent of total operating expenses (50 percent of 60 percent of total expenses). As the utility faces only 70 percent of economic costs, rates should be increased by a factor of 1.43 (100 percent divided by 70 percent) to crudely reflect this difference between rates and economic costs. Other potential distortions may be more difficult to correct (even crudely) without access to costs accounts. For example, while different types of users may be charged different rates, it may be impossible to determine whether this reflects different costs of providing a service to different types of users or cross-subsidization between user types.

E.7 Sources of Income Data Information

Income data is available from various sources; depending on the specificity, and the population density of the area. Data sources include the following:

1) County or City Level - The County and City Data Books, U.S. Bureau of the Census, 1983.

2) Census Tract Reports for each Standard Metropolitan Statistical Area.

3) Block Reports (Maps in print) and Block Group data for areas of the county which were blocked by the 1980 Census, but are not within tracts.

4) Enumeration District Reports for areas of the country (rural) which were not blocked by the 1980 Census.

5) Regional Office of the Census.

6) State Coordinating Organizations which may have compiled income data for a specific area.

7) Companies within the National Clearinghouse for Census Data Services that provide demographic studies.

County and city income figures are listed in <u>The County and City Data Book</u>, U.S. Bureau of the Census, 1983. <u>The County and City Data Book</u> shows for each county and city (defined by more than 25,000 people) the median household income for 1979.

Each standard metropolitan statistical area is broken down progressively into tracts, block groups, and blocks. The smallest unit for which income data is available from any depository library or from GPO. The reports contain both means and medians of household income from 1979.

Certain areas of the county were not tracted but were blocked. These areas may be found in unincorporated places of more than 10,000 people and in states (Georgia, Mississippi, New York, Rhode Island, and Virginia), which contracted with the Census Bureau. The unit in which income information may be found for these areas is the block group. Two sets of material should be obtained from the Census Bureau: (1) block maps, available in print and categorized by state, and (2) block group reports available as STE-1A microfiche or on computer tape. Areas not blocked in the 1980 census (i.e., rural areas) are broken down into enumeration districts that average approximately 550 people and are listed by counties within states.

Regional and state offices may also provide specialized income information. A list of the information service specialists in the Census Bureau Regional Offices and State Coordinating Organizations may be found in Appendix F.

Private demographic companies, which the Census Bureau refers to as "National Clearinghouses for Census Data Services" may also be helpful. For example, if median household income inside a 3 mile radius around a CRA were desired, a national clearinghouse would be able to provide appropriate information. A list of these organizations is available in Appendix F.

E.8 Overview of Treatment Technologies

The following discussions of treatment technologies indicate the typical area of application and limitations of particular significance and the potential problems encountered when treating water with multiple contaminants. A series of references is included that can be used for general background data. Many treatment processes, particularly those used in water polishing, develop reductions in treatment efficiencies in the presence of interfering contaminants, so that "pretreatment" is required. In existing water treatment facilities, the pretreatment requirements are met using the processes in an order which progressively removes various interferences. For example, a facility which receives a water with high levels of adsorbable organics and high suspended solids may use granular media filtration prior to carbon adsorption in an effort to minimize the levels of solids in the influent to the carbon adsorption; the load of solids to the adsorption column will disrupt this process.

If several processes in a treatment configuration have disruptive interference problems, the particular combination of processes cannot be reasonably employed to treat the water. This situation might occur if an influent contained high levels of dissolved organics and of inorganic chemical oxidants, and the treatment configuration under consideration was a combination of desalination and ion exchange. The dissolved organics, which would be removed by desalination, could severely disrupt the ion exchange efficiencies, while the chemical oxidants (removable by ion exchange) could disrupt the desalination process. This particular treatment configuration would, in this instance, be eliminated from further consideration because additional pre-treatment would be required to manage the chemical interences.

E.8.1 Air Stripping/Aeration

Air stripping and aeration can be used for removal of volatile contaminants from ground water, as well as for introduction of oxygen to the water. Air is passed through the water or the water is finely sprayed into the air, enhancing transfer of dissolved gases from the water to the air, which may be treated further or discharged. Cost effective and efficient treatment requires continuous or semi-continuous flow. The process has been used for ammonia removal, hydrogen sulfide removal, and volatile organic carbon removal in both water and wastewater treatment operations. The treatment efficiences and design are a function of the contaminant loading to the air; water ratio, the length of contact time, contaminant volatility, and temperature. Removal efficiencies of volatile organics ranging from 10 to greater than 99.0 percent have been reported in the literature.

Although air stripping is a relatively inexpensive technology for removal of volatile contaminants, its use in public water supply systems to date has been somewhat limited. This is primarily due to an absence of need for the technology, which is in wide-spread use in Superfund remedial action and wastewater treatment operations. Traditional aeration, which is in common use among public water utilities, has typically been installed to provide oxygenation of waters, and the removal of volatile contaminants is merely a beneficial side-effect.

Temperature limitations in regions experiencing severe winters may be such that air stripping and aeration processes must be housed indoors or in thermally protected facilities. If the treated water contains high levels of suspended solids (unlikely to occur with ground waters), some pre-treatment, such as filtration or pH adjustment, may be required prior to air stripping.

Aeration and air stripping pose potential air pollution problems if large amounts of volatile contaminants in the treated waters are transferred to the air. If this is a problem, emission control devices are required. Most ground waters, however, are not likely to contain concentrations of volatile contaminants sufficiently large to warrant such controls.

E.8.2 Carbon Adsorption

Carbon adsorption treatment of ground waters entails contacting the water with activated carbon, which adsorbs contaminants and removes them from solution. Granular activated carbon, used in beds or columns, is the most commonly used form, although powdered activated carbon has been used in some wastewater treatment applications. Treatment processes can use both batch and continuous feed operations. Activated carbon adsorption effectively removes many organic and inorganic contaminants from solution.

Treatment efficiencies are a function of the type of carbon used, the concentration and type of contaminants present, the length of contact time for each unit of water, and the interval between carbon regneration or replacement. Removal efficiencies ranging from 0 to greater than 99.9 percent have been reported in the literature.

Although activated carbon adsorption theoretically can provide limitless removal of contaminants, in reality there are economic limitations to the applicability of activated carbon treatment. Removal of high concentrations of contaminants may require overly frequent carbon replacement, while hard to remove contaminants may require enormous treatment facilities with several carbon contact systems: both situations may incur excessive expense, and though technically feasible would be effectively unavailable.

Influent to the carbon adsorption process must be relatively free of suspended solids and oil/grease to prevent clogging of the adsorption beds. Suspended solids of less than 50 mg/l and oil/grease of less than 10 mg/l are recommeded concentrations to avoid interferences. Biological activity in the carbon beds may become a problem in some instances, causing clogging and taste or odor generation.

Removal efficiencies in carbon adsorption systems are affected by changes in influent flow and influent chemical composition. The presence of multiple contaminants in the influent may reduce adsorption efficiency for some of the constituents, although in some instances increased removal efficiencies have been noted with multiple contaminants. For any given water to be treated, the selection of the appropriate carbon and system design requires laboratory testing to determine the specific adsorption efficiencies and interferences for that influent.

E.8.3 Chemical Precipitation

Chemical precipitation, coagulation, flocculation, and sedimentation are all interrelated processes which are most often used to remove metals and certain organics from solution. For waters containing dissolved solids, a precipitant is added which reacts with the contaminant to form a solid, or to shift solution chemistry in such a way that the contaminant solubility is reduced. The precipitated contaminant can then be removed by gravity sedimentation or mechanical solids removal processes. Commonly used precipitants include lime, caustic, soda ash, iron salts, and phosphate salts. Some waters contain colloidal suspended solids which cannot be readily removed using conventional sedimentation. Treatment of these contaminants, which are usually organic in nature, entails addition of a coagulant (usually alum, cuprous sulfate, or ferrous sulfate) that forces the suspended solids to agglomerate into larger particles, which can then be removed using gravity sedimentation. Some facilities add polymeric coagulant or precipitation aids, which have been shown to enhance removal efficiencies in some cases. Chemical precipitation processes can be run as batch or continuous flow operations. Treatment efficiencies depend upon the contaminant type and concentration present, the solution pH and temperature, the precipitants added, time and degree of mixing, and the time allowed for sedimentation.

Precipitation of metals from solution can be inhibited by the presence of chelating agents in the waters, such as humic materials (naturally occuring organic acids) or other organic compounds. This problem can be eliminated by using precipitants with stronger affinities for the metal than the complexion agent or by using pH adjustment to disrupt the metal complex.

Use of chemical precipitation processes generates a sludge which must be disposed of appropriately. Sludges containing heavy metals or certain organics may be considered to be hazardous wastes and as such should be disposed in RCRA-regulated facilities.

E.8.4 Desalination

Desalination processes remove contaminants from the influent using membranes to separate an enriched stream (high contaminant concentration) from a depleted stream. Reverse osmosis and ultrafiltration use a pressure differential to drive the separation, while electrodialysis depends on an electric field. The concentrated or enriched stream frequently requires further treatment, while the depleted stream is usually potable. Desalination processes have been used to purify waters to drinking water quality in certain regions of the country where fresh water is in short supply. The processes are in more widespread use for treatment of industrial process waters which must be of extremely high quality. Treatment efficiencies are a function of the molecular size and concentration of contaminants, strength of the separation driving force, membrane type, and system configuration. Removal efficiencies of greater than 90 percent have been reported in the literature.

Desalination processes are highly sensitive to variability in the influent, and drastic changes in pH, temperature, or suspended solids. Any of these factors can effectively reduce treatment efficiencies and the membrane life. The suspended solids in a desalination influent should be minimized to particle sizes 10 microns or less in order to prevent membrane fouling. Biological activity can severely impair the process efficiency, and disinfection may be required prior to desalination. The presence of chlorine may also disrupt efficient desalination, dechlorination or non-chlorine disinfection processes may be desired.

Desalination processes are very expensive and energy-intensive. Because of this, desalination is not frequently used for removal of contaminants which are readily removed via other treatment processes. However, for high TDS waters and waters with large dissolved molecules, these processes may provide cost effective contaminant removal.

E.8.5 Flotation

Flotation is used to remove oil and grease or suspended particles from the aqueous phase. The process involves introduction of a gas (usually air) into solution, and subsequent attachment of the gas bubbles to particulate matter which then floats to the surface. The floating particulates can be skimmed and removed for disposal or further treatment. Surfactants and pH-modifications are often used to improve process performance. Flotation is used in many public water utilities across the nation for removal of organic matter from surface waters, but the most common use of the process is removal of oils and grease from industrial petroleum wastewaters. Removal efficiencies are a function of concentration, size, mass of contaminant particles, air loading rate, types of chemical additives used, hydraulic loading rate, and skimmer design. Removal efficiencies over 95 percent have been reported in the literature.

Flotation is effective for contaminants with densities less than or near to that of water, but is relatively ineffective for contaminants which are denser than water. It is not particularly effective at removing dissolved contaminants, although chemical additives can be used to decrease contaminant solubility. If volatile contaminants are present in the influent, flotation may result in simultaneous stripping of these contaminants from solution.

E.8.6 Granular Media Filtration

Granular media filtration is widely used to separate solids from aqueous streams. Water is fed (via gravity or applied pressure) through a bed of granular media, which may consist of sand, gravel, coke, or combinations of the three. Periodically the filter is "backwashed," which removes the filtered particles into a relatively small volume of wastewater which must be disposed or treated further. Granular media filtration is commonly used in water utilities following chemical precipitation to ensure turbidity standards are met. Filtration performance depends upon the solubility of the contaminants, the strength and size of contaminant particles, the type of granular media used, the hydraulic loading rate, and the interval between backwashings. Removal to suspended solid levels less than 10 mg/l has been reported.

E.8.7 Ion Exchange

Ion exchange processes, like carbon adsorption, operate by removing contaminants from solution onto a receptor. The ion exchange process uses a chemically reactive resin which exchanges innocuous ions for the contaminant ions in solution. The reaction is reversible, which allows a facility to regenerate the ion exchange resin and reuse it. Ion exchange processes are most commonly used to generate high quality industrial processes waters, but recent applications have also included wastewater treatment and ion exchange water softening to remove hardness in drinking water supplies. Ion exchange can be used for removal of almost any ion from solution, but is not very effective for removing uncharged contaminant species. Removal efficiencies, which have been reported in excess of 99.9 percent, are dependent upon the ionic charge of the contaminants, contaminant concentration, type of resin used, hydraulic loading, and interval between resin regeneration.

Although almost any ionic contaminant can be removed using ion exchange processes, the specific ion exchange resins used are usually specific to certain types of contaminants. Resin selectivity is based on the type (positive, or negative) and degree of charge on the contaminant ions. If several types of contaminants with varying charge are present, efficient ion exchange treatment may require a series of diffrent resins.

Changes in pH or the presence of organic and inorganic complexing agents may cause certain ionic species to form uncharged or differently charged chemical complexes, which in turn can reduce the efficiency of ion exchange treatment. These problems are often overcome by adjusting pH so that the desired ionic species are present, or by pretreating the influent to remove complexing agents. Pretreatment may also be required if the influent to the ion exchange process contains excessive suspended solids which will clog the bed or foul the resin.

E.8.8 Ozonation

Ozonation is a chemical oxidation process in which the influent stream is contacted with ozone which breaks refractory (non-biodegradable) organic compounds into smaller, treatable or non-toxic compounds. Used alone or in conjunction with ultraviolet radiation, it is a highly effective means of treating dilute concentrations of organics. Because it is an expensive process to construct and operate, ozonation is not in common use in public water utilities across the nation. However, several individual water treatment systems use ozone rather than chlorine to disinfect their water supply. The process can achieve both effective disinfection and up to 99 percent removal of certain organic compounds. Ozonation effectively removes pesticides, chlorinated hydrocarbons, alcohols, chlorinated aromatics, and cyanides.

The efficiency of contaminant removal using ozonation is dependent upon the retention time of the process reactor, the ozone dose rate, the ultraviolet light dose rate, and the contaminant type and loading. Treatability studies are required prior to installation of ozonation processes to treat specific influent streams.

Ozonation is currently used by only a few public water supply systems, primarily as a disinfection process. It is an expensive process which is readily replaceable with chlorination for disinfection, but which has been gaining acceptance for use in public water supply systems because it does not cause any by-product trihalomethane formation. Lack of use of ozonation in public water supply treatment systems may be due to economic constraints and limited need for the technology.

E.8.9 Disinfection and Fluoridation

Two water treatment processes which are universally available are chlorine disinfection and fluoridation. Chlorine disinfection is the most commonly used means of destroying bacteria in public water supplies. Fluoridation of water supplies is used to prevent dental health problems.

The processes do not remove chemical contamination from the wastestream; they serve instead as preventive measures in control of disease and maintenance of public health.

E.9 Source of Information on Ecologically Vital Ground Waters

Tables E-2, E-3, and E-4 provide a list of U.S. Fish and Wildlife and State Heritage Program representatives who may be contacted to obtain information on the location of potential unique habitats when classifying ecologically-vital ground waters.

E.10 Radius of Classification Review Area

The EPA classification system utilizes a Classification Review Area with a radius of two miles from the boundary of the facility or activity. The radius is intended to be large enough to identify wells and surface waters which are high interconnected with ground water under the facility. The following sources of information were examinaed in the selection of this radius:

- A survey of existing contaminant plumes documented through investigations of spills, leaks and discharges
- A survey of the distances to downgradient surface waters from hazardous-waste facilities; and
- Calculations of the distances from which pumping wells draw ground water under different hydrogeologic settings.

These sources are described below.

Plume Survey

A survey of contaminant plume geometries, (i.e., length, width and depth) was prepared in connection with the development of a stochastic model of corrective action costs at hazardous-waste management facilities (Geraghty & Miller, Inc., 1984). The plume survey provides generalized information on the distances contaminants have been known to migrate regardless of time, source type or hydrogeologic setting. This was viewed as an indication of the area which may be affected if contaminants were accidentally released from the site.

TABLE E-2

LIST OF OFFICES OF ENDANGERED SPECIES
U.S. FISH AND WILDLIFE SERVICES

The Fish and Wildlife Service, a unit of the U.S. Department of the Interior, has been delegated the main responsibility for coordinating national and international efforts on behalf of Endangered Species.

In the case of marine species, however, actions are taken in cooperation with the Secretary of Commerce, through the Director of the National Marine Fisheries Service Similarly, in the area of import/export enforcement for Endangered plants, Interior cooperates with and is assisted by the Department of Agriculture through the Animal and Plant Health Inspection Service (Liaison listed on page 7).

PROGRAM MANAGER--ENDANGERED SPECIES--Mr. Ronald E. Lambertson
Associate Director-Federal Assistance
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Washington, D.C. 20240
Telephone: 202/343-4646

CATEGORY COORDINATOR--ENDANGERED SPECIES--Mr. Roman Koenings
Deputy Associate Director--Federal Assistance
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Washington, D.C. 20240
Telephone: 202/343-4646

Mr. John M. Murphy, Chief
Office of Program Development and Administration
U.S. Fish and Wildlife Service
1000 North Glebe Road, Room 629
Arlington, Virginia
Telephone: 703/235-1726, 7, 8

Mailing Address for Office of Program Development and Administration

U.S. Fish and Wildlife Service
Washington, D.C. 20240

Mr. John L. Spinks, Jr. Chief
Office of Endangered Species
U.S. Fish and Wildlife Service
1000 North Glebe Road, Suite 500
Arlington, Virginia
Telephone: 703/235-2771, 2

Mailing Address for Office of Endangered Species

U.S. Fish and Wildlife Service
Washington, D.C. 20240

Dr. Kenneth R. Russell, Chief, Branch of Biological Support
Telephone: 703/235-1975, 6, 7

Mr. Brian Cole, Chief, Branch of Management Operations
Telephone: 703/235-2760, 1, 2

Chief
Federal Wildlife Permit Office
U.S. Fish and Wildlife Service
1000 North Glebe Road, Suite 600
Arlington, Virginia
Telephone: 703/235-1937, 8, 9

Mailing Address for Federal Wildlife Permit Office

U.S. Fish and Wildlife Service
Washington, D.C. 20240

Mr. Clark Bavin, Chief
Division of Law Enforcement
U.S. Fish and Wildlife Service
1735 K Street, NW., 3rd Floor
Washington, D.C.
Telephone: 202/343-9242

Mailing Address for Division of Law Enforcement

P.O. Box 28006
Washington, D.C. 20005

Mr. Thomas Striegler, Special-Agent-in-Charge, Branch of Investigations
Telephone: 202/343-9242

Dr. Richard L. Jachowski, Chief
Office of the Scientific Authority
U.S. Fish and Wildlife Service
1717 H Street, NW., Room 536
Washington, D.C.
Telephone: 202/653-5948, 49, 50

Mailing Address for Office of the Scientific Authority

U.S. Fish and Wildlife Service
Washington, D.C. 20240

Regional Endangered Species Coordinators:

The U.S. Fish and Wildlife Service is comprised of seven Regional Offices. (See map on inside back cover for geographic boundaries.) Each office has a senior official who has been designated as a Regional Endangered Species Coordinator. Additionally, each of the regions has several Field Offices. Problems of a local nature should be referred to these offices.

Region 1 Regional Director (Attention: Mr. Sanford R. Wilbur
Endangered Species Specialist)
U.S. Fish and Wildlife Service
Suite 1692, Lloyd 500 Building
500 NE. Multnomah Street
Portland, Oregon 97232
Telephone: 503/231-6131 (FTS: 8/429-6131)

Field Offices

California
1230 "N" Street, 14th Floor
Sacramento, California 95814
Telephone: 916/440-2791 (FTS: 8/448-2791)

Idaho
4696 Overland Road, Room 566
Boise, Idaho 83705
Telephone: 208/334-1806 (FTS: 8/554-1806)

Nevada
Great Basin Complex
4600 Kietzke Lane, Building C
Reno, Nevada 89502
Telephone: 702/784-5227 (FTS: 8/470-5227 or 5228)

Washington/Oregon
Building-3, 2625 Parkmont Lane
Olympia, Washington 98502
Telephone: 206/753-9444 (FTS: 8/434-9444)

Pacific Islands Administrator
300 Ala Moana Boulevard, Room 5302
P.O. Box 50167
Honolulu, Hawaii 96850
Telephone: 808/546-5608 (FTS: 8/546-5608)

Region 2 Regional Director (Attention: Mr. James Johnson
Endangered Species Specialist)
U.S. Fish and Wildlife Service
500 Gold Avenue, SW.
P.O. Box 1306
Albuquerque, New Mexico 87103
Telephone: 505/766-3972 (FTS: 8/474-3972)

Field Offices

Arizona
2934 West Fairmont Avenue
Phoenix, Arizona 85017
Telephone: 602/241-2493 (FTS: 8/261-2493)

New Mexico
P.O. Box 4487
Albuquerque, New Mexico 87196
Telephone: 505/766-3966 (FTS: 8/474-3966)

Oklahoma/Texas
222 South Houston, Suite A
Tulsa, Oklahoma 74127
Telephone: 918/581-7458 (FTS: 8/736-7458)

Texas
c/o CCSU, Box 338
6300 Ocean Drive
Corpus Christi, Texas 78411
Telephone: 512/888-3346 (FTS: 8/734-3346)

Fritz Lanham Building, Room 9A33
819 Taylor Street
Fort Worth, Texas 76102
Telephone: 817/334-2961 (FTS: 8/334-2961)

Region 3 Regional Director (Attention: Mr. James M. Engel
Endangered Species Specialist)
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111
Telephone: 612/725-3276 (FTS: 8/725-3276)

Region 4 Regional Director (Attention: Mr. Alex B. Montgomery
Endangered Species Specialist)
U.S. Fish and Wildlife Service
The Richard B. Russell Federal Building
75 Spring Street, SW.
Atlanta, Georgia 30303
Telephone: 404/221-3583 (FTS: 8/242-3583)

Field Offices

Alabama/Arkansas/Louisiana/Mississippi
Jackson Mall Office Center
300 Woodrow Wilson Avenue, Suite 3185
Jackson, Mississippi 39213
Telephone: 601/960-4900 (FTS: 8/490-4900)

Florida/Georgia
2747 Art Museum Drive
Jacksonville, Florida 32207
Telephone: 904/791-2580 (FTS: 8/946-2580)

Kentucky/North Carolina/South Carolina/Tennessee
Plateau Building, Room A-5
50 South French Broad Avenue
Asheville, North Carolina 28801
Telephone: 704/258-2850 ext. 382 (FTS: 8/672-0321)

Puerto Rico/Virgin Islands
P.O. Box 3005
Marina Station
Mayaguez, Puerto Rico 00709
Telephone: 809/833-5760 (FTS: 8/967-1221)

Region 5 Regional Director (Attention: Mr. Paul Nickerson
Endangered Species Specialist)
U.S. Fish and Wildlife Service
Suite 700, One Gateway Center
Newton Corner, Massachusetts 02158
Telephone: 617/965-5100 ext. 316 (FTS: 8/829-9316, 7, 8)

Field Offices

Connecticut/Maine/Vermont/Massachusetts
New Hampshire/Rhode Island
P.O. Box 1518
Concord, New Hampshire 03301
Telephone: 603/224-9558, 9 (FTS: 8/834-4726)

District of Columbia/Delaware/Maryland
Virginia/West Virginia
1825 Virginia Street
Annapolis, Maryland 21401
Telephone: 301/269-6324 (FTS: 8/922-4197)

New Jersey/Pennsylvania
112 West Foster Avenue
State College, Pennsylvania 16801
Telephone: 814/234-4090 (FTS: 8/727-4621)

New York
100 Grange Place
Cortland, New York 13045
Telephone: 607/753-9334 (FTS: 8/882-4246)

Region 6 Regional Director (Attention: Mr. Don Rodgers
Endangered Species Specialist)
U.S. Fish and Wildlife Service
P.O. Box 25486, Denver Federal Center
Denver, Colorado 80225
Telephone: 303/234-2496 (FTS: 8/234-2496)

Field Offices

Colorado/Utah
Room 1406, Federal Building
125 S. State Street
Salt Lake City, Utah 84138
Telephone: 801/524-4430 (FTS: 8/588-4430)

Kansas/Nebraska/North Dakota/South Dakota
223 Federal Building
P.O. Box 250
Pierre, South Dakota 57501
Telephone: 605/224-8692 (FTS: 8/782-5226)

Montana/Wyoming
Federal Building, Room 3035
316 North 26th Street
Billings, Montana 59101
Telephone: 406/657-6059 or 6062 (FTS: 8/657-6059)

Region 7 Regional Director (Attention: Mr. Dennis Money
Endangered Species Specialist)
1011 E. Tudor Road
Anchorage, Alaska 99503
Telephone: 907/786-3435 (FTS: 8/907/786-3435)

TABLE E-3

LIST OF STATE NATURAL HERITAGE PROGRAM OFFICES
October 1985

Nongame Branch
ARIZONA HERITAGE PROGRAM
Arizona Game & Fish Department
2222 W. Greenway Rd.
Phoenix, AZ 85023
602/942-3000 x245
Branch Supervisor: Terry Johnson
Zoologist: Dick Todd
Zoologist: Cecil Schwalbe
Zoologist: Jim Brooks
Data Manager: Rich Glinski
Habitat Spec.: Bruce Palmer
Wildlife Rehab: Cindy Dorothy

ARKANSAS NATURAL HERITAGE INVENTORY
225 E. Markham, Suite 200
Little Rock, AR 72201
501/371-1706
Coordinator/Zoologist: Ken Smith
Ecologist: Tom Foti
Botanist: Steve Orzell
Data Manager: Cindy Osborne

CALIFORNIA NATURAL DIVERSITY DATABASE
c/o CA Dept. of Fish & Game
1416 9th Street
Sacramento, CA 95814
916/322-2493
Section Leader: Steve Nicola
Prog. Manager/Ecol: Deborah Jensen
Zoologist: Larry Eng
Res.Asst/Zool: Carrie Shaw
Aquatic Ecol: John Ellison
Ecologist: Bob Holland
Botanist: Jim Shevock
Asst.Botanist: Cindy Roy
Data Handler: Sylvia Gude
Element Pres.Plan: Roxanne Fittman
End.Plants Coord: Susan Cochrane
SNAP Coordinator: Chris Unkel

COLORADO NATURAL HERITAGE INVENTORY
Dept. of Natural Resources
1313 Sherman St., Rm.718
Denver, CO 80203
303/866-3311
Botanist: Steve O'Kane
Ecol: Susan Galatowitsch
303/860-3142

CONNECTICUT NATURAL DIVERSITY DATABASE
Natural Resources Center
Dept. of Environmental Protection
State Office Building, Rm. 553
165 Capitol Avenue
Hartford, CT 06106
203/566-3540
Biologist/Data Man: Nancy Murray
Ecologist: Ken Metzler
Data Handler: Megan Rollins

FLORIDA NATURAL AREAS INVENTORY
254 E. 6th Avenue
Tallahassee, FL 32303
904/224-8207
Coordinator: Steve Gatewood
Zoologist: Dale Jackson
Botanist: Dennis Hardin
Res.Spec/Data Manager: Jim Muller
Secretary: Judith Lyons

* **HAWAII HERITAGE**
1116 Smith St., #201
Honolulu, HI 96817
808/537-4508
Director: Audrey Newman

IDAHO NATURAL HERITAGE PROGRAM
4696 Overland Rd., Suite 518
Boise, ID 83705
208/334-3402 or 3649
Coordinator/Zool: Craig Groves
Botanist/Ecologist: Steve Caicco
Data Handler/Biol: Pam Peterson

INDIANA HERITAGE PROGRAM
Div. of Nature Preserves, IN DNR
612 State Office Bldg.
Indianapolis, IN 46204
317/232-4078
Coordinator/Bot: Jim Aldrich
Ecologist: Mike Homoya
Plant Ecologist: Tom Post
Zoologist: Brian Abrell

IOWA NATURAL AREAS INVENTORY
State Conservation Commission
Wallace State Office Bldg.
Des Moines, IA 50319
515/281-8524
Ecologist: John Pearson
Data Handler: John Fleckenstein
Zoologist: Daryl Howell
Botanist: Mark Leoschke

KENTUCKY HERITAGE PROGRAM
KY Nature Preserves Commission
407 Broadway
Frankfort, KY 40601
502/564-2886
Director: Richard Hannan
Botanist: Marc Evans
Zoologist: Ronald Cicerello
Ornithol: Brainard Palmer-Ball
Aquatic Biol: Bill Fisher
Secretary: Julie Smither

LOUISIANA NATURAL HERITAGE PROGRAM
Department of Natural Resources
Coastal Management Division
P.O. Box 44124
Baton Rouge, LA 70804-4124
504/342-4602
Coordinator/Ecol: Nancy Jo Craig
Zoologist: Gary Lester
Botanist: Annette Parker
Data Manager: Alanea Williams

* **MAINE NATURAL HERITAGE PROGRAM**
Maine Chapter
122 Main Street
Topsham, ME 04086
207/729-5181
Coordinator: John Albright
Data Manager/Bot: Amy Ostenbrock

MARYLAND NATURAL HERITAGE & ENVIRONMENTAL REVIEW
Dept. of Natural Resources
C-3, Tawes State Office Bldg.
Annapolis, MD 21401
251-1402 /2556 D.C.DIRECT DIAL
301/269-3656
Coordinator/Bot: Dan Boone
Environmental Spec: Arnold Norden
Man. Area Spec: [illegible] Richerson

* **MODEL NATURAL HERITAGE PROGRAM**
The Nature Conservancy
1800 N. Kent St., Suite 800
Arlington, VA 22209
703/841-5307
Zoologist: David Wilcove
Botanist: Mary Palmer
Ecologist: being hired

MASSACHUSETTS HERITAGE PROGRAM
Div. of Fisheries & Wildlife
100 Cambridge St.
Boston, MA 02202
617/727-9194
Coordinator/Ecol: Henry Woolsey
Botanist: Bruce Sorrie
Zoologist: Scott Melvin
Data Manager: Joanne Tribble
Hab.Prot.Spec: Annie Marlowe

MICHIGAN NATURAL FEATURES INVENTORY
Mason Building, 5th floor
Box 30028
Lansing, MI 48909
517/373-1552
Coordinator/Bot: Sue Crispin
Ecologist: Kim Chapman
Zoologist: Leni Wilsmann
Data Manager: Stu Ouwinga

MINNESOTA NATURAL HERITAGE PROGRAM
Department of Natural Resources
Box 6
St. Paul, MN 55155
612/296-4284
Coordinator: Barbara Coffin
Botanist: Welby Smith
Ecologist: Keith Wendt
Zoologist: Lee Pfannmuller
Data Manager: Carmen Converse

MISSISSIPPI NATURAL HERITAGE PROGRAM
111 N. Jefferson St.
Jackson, MS 39202
601/354-7226
Coord/Bot/Wild.Bio: Ken Gordon
Zoologist: Bob Jones
Ecologist: Jim Wiseman

MISSOURI NATURAL HERITAGE INVENTORY
Missouri Dept. of Conservation
P.O. Box 180
Jefferson City, MO 65102
314/751-4115
Coordinator: Mike Sweet
Biologist: Dennis Figg-X310
Secretary: Diane Munsterman

MONTANA NATURAL HERITAGE PROGRAM
State Library Building
1515 E. 6th Ave.
Helena, MT 59620
406/444-3009
Coordinator/Zool: David Genter
Botanist: Steve Shelly
Ecologist: Nancy Grulke
Data Tech/Sec: Lisa Sheppard

NAVAJO NATURAL HERITAGE PROGRAM
Box 2429
Window Rock, AZ 86515-2429
602/871-6453 or 6449
Acting Coord/Botanist: Donna House
Data Manager: Virgil Link
Zoologist: vacant

(* = Proto-Heritage Programs)

NEVADA NATURAL HERITAGE PROGRAM
Dept. of Conservation & Natural Resources
c/o Div. of State Parks
Capitol Complex, Nye Bldg.
201 S. Fall St.
Carson City, NV 89710
702/885-4360
Coordinator/sci.: being hired
Research sci.: being hired

NEW HAMPSHIRE NATURAL HERITAGE PROGRAM
c/o Society for the Protection of N.H. Forests
54 Portsmouth Street
Concord, NH 03301
603/224-9945
Coordinator/Bot: Frances Brackley
Data Manager: Edie Hentcy

NEW JERSEY NATURAL HERITAGE PROGRAM
Office of Natural Lands Management
109 W. State St.
Trenton, NJ 08625
609/984-1339 or 1170
Coordinator/Ecol: Thomas Breden
Botanist: David Snyder
Zoologist: Jim Sciascia
Data Manager: Jane Saks
Data Handler: Elena Williams

NEW MEXICO NATURAL RESOURCES SURVEY SECTION
Villagra Bldg.
Santa Fe, NM 87503
505/827-7862
Coordinator: Cathy Carruthers
Botanist: Paul Knight-7850
Botanist: Anne Cully
Data Handler: Leslie Price
Mgmt. Analyst: Denise Gross

NEW YORK NATURAL HERITAGE PROGRAM
Wildlife Resources Center
Delmar, NY 12054-9767
518/439-8014 x203
Coordinator/Zool: Pat Melhop
Ecologist: Carol Reschke
Botanist: Steve Clemants
Data Manager: Rachel Pleuthner
L.I. Botanist: Bob Zaremba
367-3225

NORTH CAROLINA NATURAL HERITAGE
Dept. of Natural & Economic Res.
Div. of State Parks
Box 27687
Raleigh, NC 27611
919/733-7795
Coordinator: Charles E. Roe
Botanist: Laura Mansberg
Ecologist: Alan Weakley
Protection Spec: Julie H. Moore
Wetlands Inv.Res.Spec: Steven Leonard
Zoologist: Harry LeGrand, Jr.
Inv. Info. Spec: Mike Schafale

NORTH DAKOTA NATURAL HERITAGE INVENTORY
N.D. Game & Fish Department
100 N. Bismarck Expressway
Bismarck, ND 58501
701/221-6310
Coordinator/Zool: Randy Kreil
Botanist: Alexis Duxbury
Plant Ecologist: Bonnie Heidel
Data Manager: Patsy Crooke

OHIO NATURAL HERITAGE PROGRAM
OH DNR, Div. of Nat. Areas & Pres.
Fountain Square, Bldg. F
Columbus, OH 43224
614/265-6453
Coordinator: Bob McCance
Botanist: Allison Cusick
Botanist: Jim Burns
Zoologist: Dan Rice
Plant Ecologist: Dennis Anderson
Data Supervisor: Pat Jones
Data Specialist: MaryAnn Silagy
Data Specialist: Lauren McEleney

OKLAHOMA NATURAL HERITAGE PROGRAM
Oklahoma Tourism & Recreation Dept.
500 Will Rogers Bldg.
Oklahoma City, OK 73105
405/521-2973
Coord/Stat-Analyst: Lela Brown

OREGON NATURAL HERITAGE PROGRAM
Oregon Field Office
1234 NW 25th Avenue
Portland, OR 97210
503/228-9550
Coord/Ecologist: Jimmy Kagan
Botanist: Sue Yamamoto
Zoologist: Connie Levesque

PENNSYLVANIA NATURAL DIVERSITY INVENTORY
Bureau of Forestry
Department of Environmental Resources
34 Airport Road
Middletown, PA 17057
717/783-1712
Coordinator/Ecologist: Tom Smith
Zoologist: Anthony Wilkinson

PROGRAMA PRO-PATRIMONIO NATURAL
Apartado 5887
Puerta de Tierra, Puerto Rico 00906
809/724-0960
Coord/Zoologist: Peter Ortiz
Bot/Data Man: Vicente Quevedo
Secretary: Myrta Hernandez

RHODE ISLAND HERITAGE PROGRAM
Dept. of Environmental Mgmt.
Div. of Planning & Development
22 Hayes St.
Providence, RI 02903
401/277-2776
Coordinator/Bot: Rick Enser
Zoologist: Chris Raithel

SOUTH CAROLINA HERITAGE TRUST
S.C. Wildl.& Marine Resources Dept.
P.O. Box 167
Columbia, SC 29202
803/758-0014
Coord/Zool: Steve Bennett
Fish & Wildl.Biol: John Cely
Envir.Planner: Stu Greeter
Botanist: Doug Rayner
Ecologist: John Nelson
F&W Bio/Preserve Mgr: Jim Sorrow
Secretary: Kaye Dial Daniels

SOUTH DAKOTA NATURAL HERITAGE
S.D. Dept. of Game, Fish & Parks
Div. of Parks & Recreation
Sigurd Anderson Bldg., B-114
Pierre, SD 57501
605/773-4226
Botanist: David Or
Data Spec: George [illegible]

(TENNESSEE HERITAGE PROGRAM)
ECOLOGICAL SERVICES DIVISION
TN Department of Conservation
701 Broadway
Nashville, TN 37203
615/742-6545
Director: Dan Eager
Zoologist: Paul Hamel
Plant Ecol/Prot.Plan: Larry Smith
Botanist: Paul Somers
Wildlife Ecol: Daryl Durham
Data Base Manager: Dave Shupe
Aq.Bio/Pro.Rev.Coor: Roberta Hylton

TEXAS NATURAL HERITAGE PROGRAM
General Land Office
Stephen F. Austin Bldg.
Austin, TX 78701
512/475-0660, 0661, 0621, 0800
Asst.Deputy Commissioner/
Land Mgmt.Div: Ben Brown
512/475-1539
Coordinator: Tina Bondy
Zoologist: Rex Wahl
Ecologist: David Diamond
Botanist: Jackie Poole
Data Manager: Robert Murphy
Secretary: Jackie Soliz

TVA REGIONAL HERITAGE
Office of Natural Resources
Norris, TN 37828
615/494-9800
Coordinator: William H. Redmond-X2613
Project Manager: J. Ralph Jordan
Botanist: Joseph L. Collins
Nat.Areas Coord: Judith B. Powers
Zoologist: Charles P. Nicholson

*VERMONT NATURAL HERITAGE PROGRAM
Vermont Field Office
138 Main Street
Montpelier, VT 05602
802/229-4425
Coordinator: Marc DesMeules
Ecologist/Data Man: Liz Thompson

WASHINGTON NATURAL HERITAGE PROGRAM
Department of Natural Resources
Mail Stop EX-13
Olympia, WA 98504
206/753-2448
Coordinator/Bot: Mark Sheehan
Ecologist: Linda Kunze
Plant Ecologist: Reid Schuller
Secretary: Charlotte Nelson
Habitat Preserv.Spec: Betty Roderick

WEST VIRGINIA WILDLIFE/HERITAGE DATABASE
Wildlife Resources Division
DNR Operations Center
P.O. Box 67
Elkins, WV 26241
304/636-1767
Asst. Director: Pete Zurbuch
Coordinator/Ecol: Brian McDonald
Data Handler: Sandra Mehringer
Botanist: Carrie Rouse

WISCONSIN NATURAL HERITAGE PROGRAM
Endangered Resources/4
Dept. of Natural Resources
101 S. Webster St., Box 7921
Madison, WI 53707
608/266-0924
  Zoologist: Bill Smith
  Ecologist: Eric Epstein
  Botanist: June Dobberpuhl
  Data Manager: Kathy Bleser

WYOMING NATURAL HERITAGE PROGRAM
1603 Capitol Avenue, Rm.323
Cheyenne, WY 82001
303/860-9142
  Coord/Botanist: vacant

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LIST OF ADDITIONAL REFERENCES

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U.S. Fish and Wildlife Service, Contaminant Issues of Concern - National Wildlife Refuges, January 1986.

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40 CFR 270.3(c), EPA Administered Permit Programs: The Hazardous Waste Permit Program.

Guidance on Remedial Investigations Under CERCLA, Chapter 9, EPA/540/G-85/002, June 1985.

Guidance on Feasibility Studies Under CERCLA, Chapter 6, EPA/540/G-85/003, June 1985.

The data base for the survey included ground-water quality investigations, consultant reports, and other publically-available literature (e.g., scientific journals). The availability of data was limited by the confidential nature of many privately-funded contamination investigations and the relatively small number of off-site investigations conducted by the government prior to the implementation of the Superfund program.

The survey found 50 contaminant plumes containing inorganic and organic contaminants. Hydrocarbon plumes consisted of dissolved and liquid phase (undissolved) materials. The sources of the plumes were spills, leaks and discharges from diverse sources including municipal and industrial sites, transportation accidents and unknown sources. Plume boundaries were defined as a detectable increase above background quality.

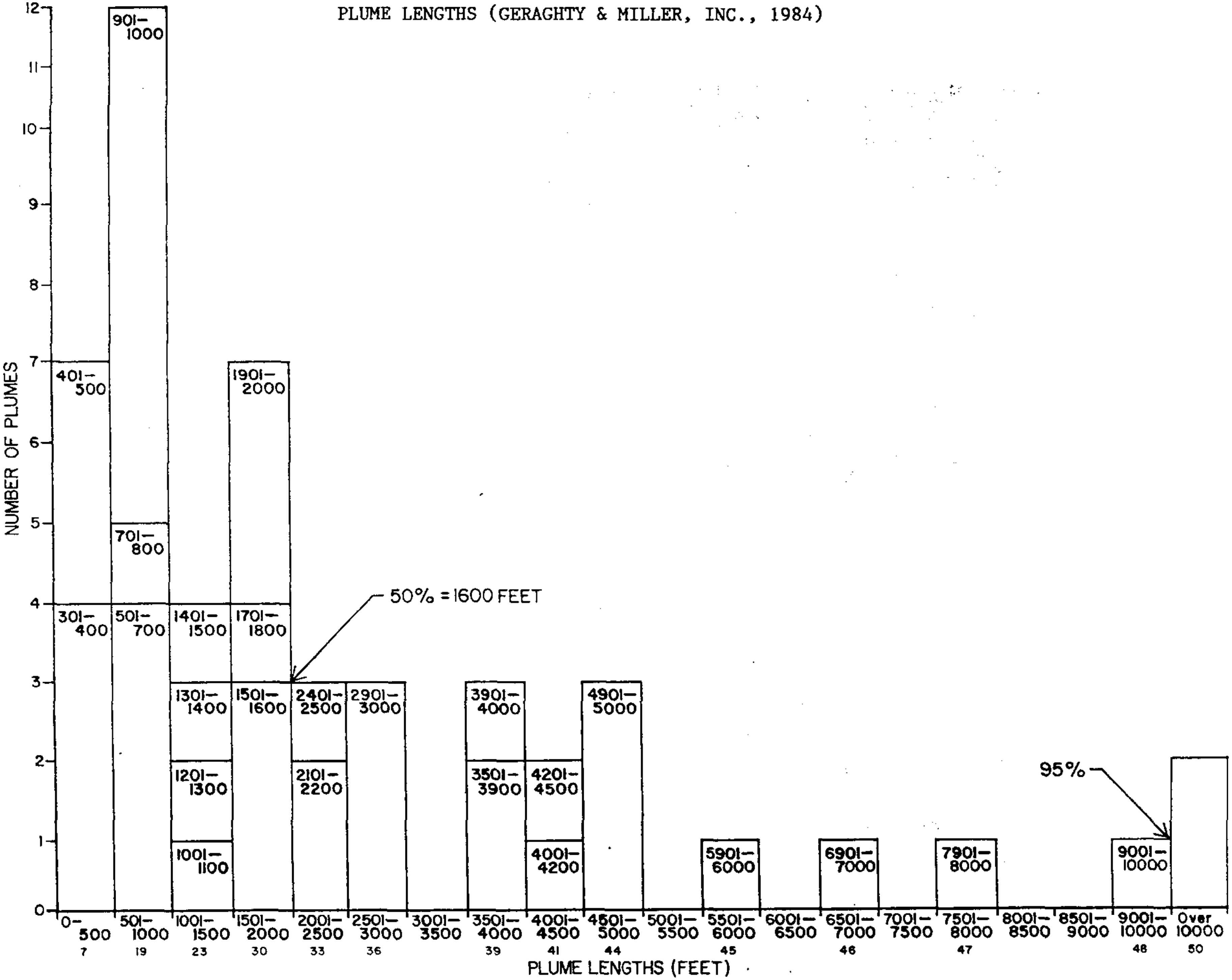
The survey showed that the median plume length was 1600 feet. Ninety-five per cent of the plumes were less than two miles in length. A histogram of plume lengths is provided in Figure E-1.

The data were too limited to determine whether the plumes in this survey had reached their maximum lengths. Theoretically, if a contamination source is continuous and the contaminant is not degraded, transformed, or immobilized in route, the plume length will eventually be equal to the distance to a downgradient discharge point. Other factors which could prevent plumes from reaching their naural discharge points include insufficient time since the contaminant release and the implementation of an effective remedial program. In some cases a steady-state condition may be reached between contaminant input by the source and dilution due to recharge. While it is now known whether the plumes in this survey had reached equilibrium, it is not likely due to their random selection that any one of the above factors had any unusual degree of influence on the results.

Distance to Downgradient Surface Waters

ICF, Inc., conducted a survey of 117 hazardous-waste management facilities for development of the EPA Liner/ Location Model (U.S. EPA, 1985). For each site, the downgradient distance to surface waters (e.g., lakes, streams, ocean, bay or marsh). This information provides insight into the distance at which a flow boundary for the shallow groundwater system is likely to be encountered. Thus, limited the area potentially impacted by a facility.

FIGURE E-1
PLUME LENGTHS (GERAGHTY & MILLER, INC., 1984)



Some of the facilities int he survey were included in EPA's "site visit" facility survey. Other sites were selected from among available Part B Permits. A site was included in the survey only if it provided information sufficient to operate the liner/location model (e.g., comprehensive facility design parameters and hydrogeologic information). Facility sites were located on U.S.G.S. topographic maps using latitude and longitude data. G&M assisted ICF by identifying the general direction of ground-water flow from the site on the topo map. Figure E-2 shows the frequency distribution histogram for distance to down-gradient surface waters. Ninety-five percent of these distances are less than two miles.

Pumping Well Capture Zones

One of the criteria for establishing the radius of the Classification Review Area was to identify highly inter-connected ground-water resources. One test of intercon-nection is the capture of ground water by a pumping well. It is presumed that all of the area supplying water to a pumping well should be placed in one classification.

All ground water within a flow system between a well and the upgradient ground-water divide may be assumed to be potentially flowing into the well. In addition, wells reverse ground-water flow and capture ground water from downgradient locations as well as "lateral" locations (perpendicular to the regional flow direction, see Figure E-3). Thus, the well capture zone extends in all directions from the well. To determine whether a facility to be classified may fall within a well capture zone it is, therefore, necessary to perform an inventory of wells in all directions from the site, not just in a downgradient direc-tion.

Site-specific data would be required to establish with confidence whether a well is drawing ground water from a site. Optimally, pumping test results and accurate water table data should be obtained. In many cases calculations would need to be supplemented by modelling to estimate the area with accuracy. Such data might be used in subdividing a classification review area; however, the initial area must be large enough to identify all wells to be evaluated.

To determine whether the two-mile radius would satis-factorily identify water-supply wells capturing water from under a site (a formula developed by Todd, 1976) was used to determine the generalized dimensions of well capture zones under different hydrogeologic conditions. The formula,

FIGURE E-2
DOWNGRADIENT DISTANCE TO SURFACE WATER
(SOURCE: EPA, 1985)

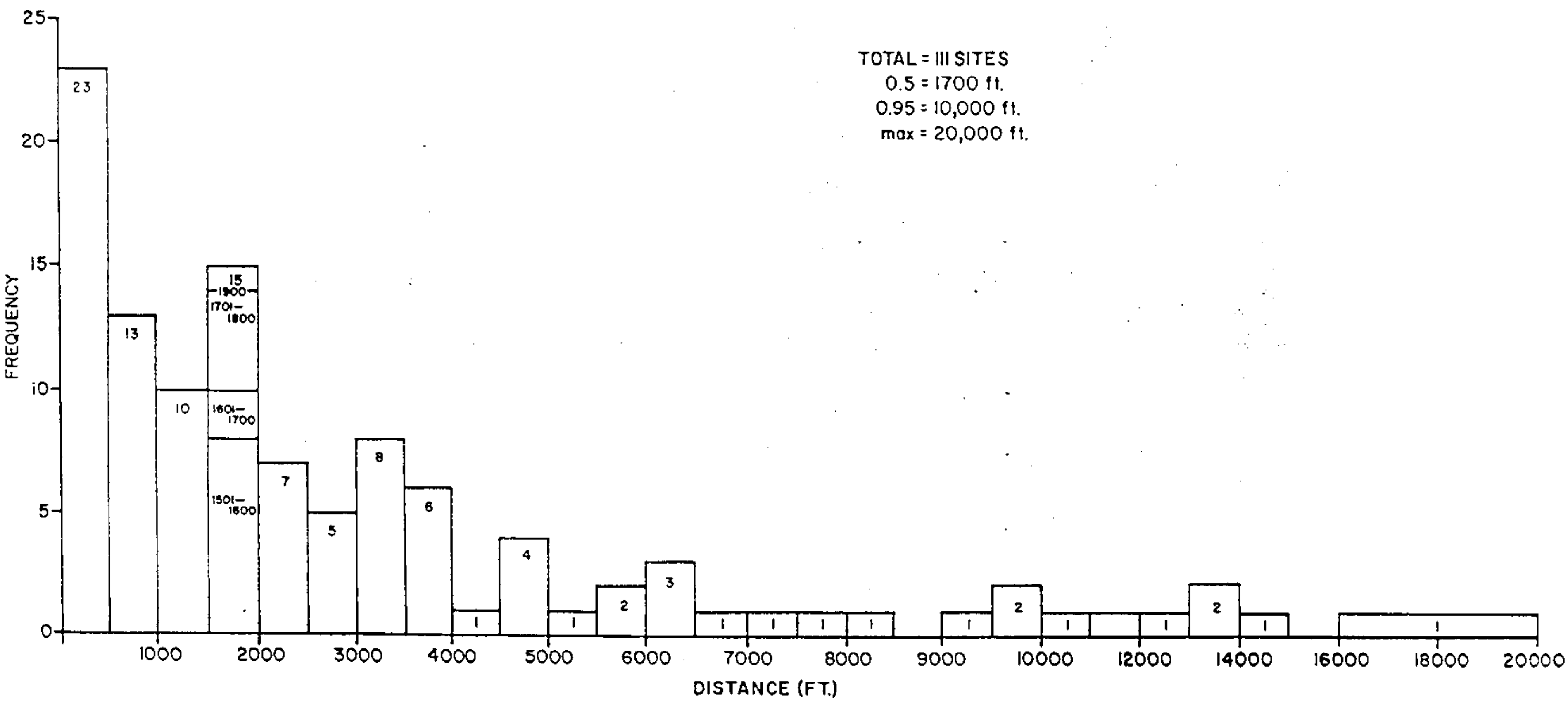
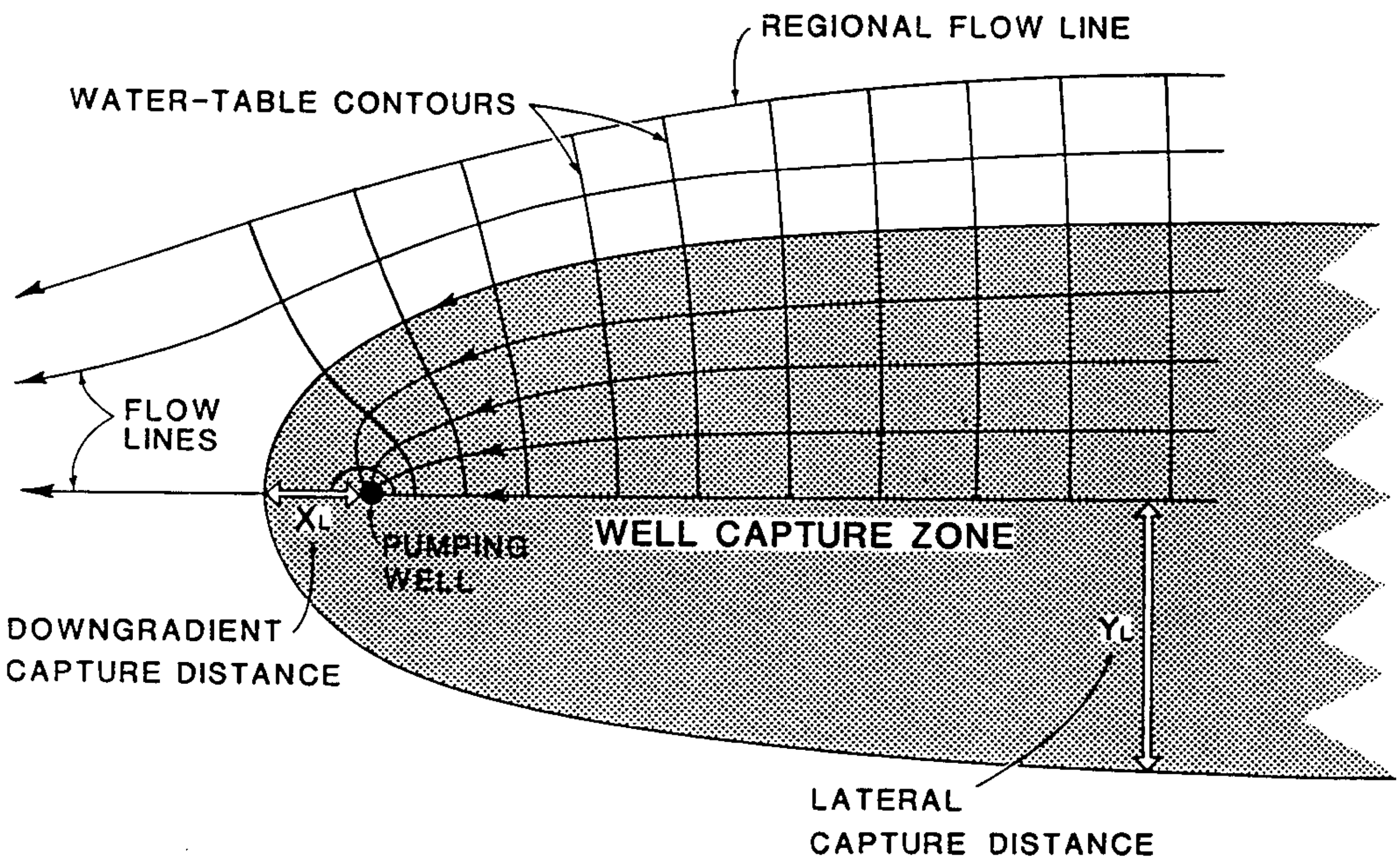


FIGURE E-3
WELL CAPTURE ZONE (FROM TODD, 1976)



illustrated in Exhibit E-5, provides a calculation of the maximum downgradient extent of well capture (XL) and the lateral distance (YL) (perpendicular to non-pumping ground-water flow gradients). Lateral and downgradient capture distances were calculated for a range of transmissivities and water-table gradients under pumping conditions of .5 to 3.0 mgd. Incompatable well yields and transmissivities were not used. Table E-5 shows the results of the calculations.

The well yields were selected to represent the common range of pumping rates for water supply wells (U.S. Geological Survey, 1984). With the exceptions noted below, water-supply wells are generally smaller than 2 mgd. The largest lateral capture distance for a 2.0 mgd supply well for the transmissivities and gradients examined is two miles. Thus, the two-mile radius would identify the majority of individual water-supply wells which could be drawing water from under a proposed facility or site in directions other than the downgradient direction.

> NOTE: Exceptions include the basalt aquifers of the Columbia Plateau and Hawaii, where common well sizes are up to 4 mgd and some may exceed 18 mgd; the Floridan Aquifer in Florida and Georgia where common yields are up to 7 mgd and may exceep 28 mgd; and the Chicot aquifer of the Lake Charles formation in Louisiana where common yields up to 3.5 mgd are found. Other regionally extensive high-yielding aquifers where wells may exceed 2 mgd include the Texas Edwards aquifer, thick members of the Atlantic and Gulf Coastal Plains, alluvium and older sedimentary basins in California and the Sparta Sands in Arkansas.

In summary, the plume survey and survey of distances to discharge boundaries support the two-mile radius in the downgradient direction. The plume data indicates that distance that contaminants are known to migrate in problem concentrations and the distance to discharge points data indicate the likelihood that a flow boundary will be intercepted. Pumping well capture distances provide the basis for including lateral and upgradient areas in the review area. Thus, the two-mile radius provides an initial identification of potentially highly interconnected ground water related to a site under classification.

TABLE E-5
LATERAL AND DOWNGRADIENT WELL CAPTURE DISTANCE (in feet)
(after Todd, 1976)

		Transmissivity/Gradient (ft/mi)		
		10,000/30-50	50,000/10-30	100,000/5-10
.5 MGD	Lateral	4400-2640	2640-880	2640-1320
	Downgradient	1400-840	840-280	840-420
1.0 MGD	Lateral	N.A.	5280-1760	5280-2640
	Downgradient	N.A.	1680-560	1680-840
2.0 MGD	Lateral	N.A.	10,560-3520	10,560-5280
	Downgradient	N.A.	3360-1120	3360-1680
3.0 MGD	Lateral	N.A.	15,840-5280	15,840-7920
	Downgradient	N.A.	5040-1680	5040-2520

Governing Equations

Lateral Distance $Y_L = Q/2Ti$
Downgradient Distance $X_L = Q/2\ Ti$

Y_L = ft
X_L = ft
Q = gpd
T = gpd/ft

N.A. = Not applicable

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